POWER

Vol. 44 NEW YORK, OCTOBER 17, 1916 No. 16

KEEP POLISHING

MY FIREMAN is an energetic young chap who is possessed of a consuming ambition to better himself in his chosen line of work. One day he came to me and asked me to explain certain features of our switchboard arrangement.

"Why," said I, "that's very simple. You see, it is like this Now, that is—ahem——."

Did you ever have anyone plump a question at you that you should have been able to answer right off the reel, and when you made the attempt you found you'd have to study about it for awhile? Didn't it give you a kind of foolish feeling? Didn't it make you say to yourself: "Well, I'll be galvanized! Here I've gone and rusted up on a simple matter like that. Fine example I am setting these men who come to me to get posted! Believe me, I'm going to go over this plant from one end to the other. and when I get through even the Chief won't be afraid to come to me for details. I'll be a walking encyclopedia!"

Well, that's the way I felt when the fireman put his question about the switchboard. Here I was, posing as an engineer, responsible during my shift for all the equipment in the plant, and yet I couldn't explain, without stopping to figure awhile, what he wanted to know. I felt thoroughly ashamed of myself and am not entirely over it yet.

How's that? Oh, don't pity me. These rust spots are mighty easy to overlook. More than likely you, yourself, have a few about that need attention. Get busy—find them and brighten them up. If you don't, someone who places much confidence in you will suddenly want to know something—BANG—just like that! And then the rust will show up so glaringly that even your questioner will notice it.

KEEP POLISHING!

Contributed by H. G. GIBSON, Washington, D. C.

Stoking Small Anthracite Coal

By Warren O. Rogers

SYNOPSIS—An easy method of firing small-sized anthracite coal without shoveling it into the furnace. The firemen pull a lever to let down coal, open the firing gate and merely spread the fuel with a light hoe. Leveling of the fires is done as their condition demands, with a light leveling tool.

A great deal has been written regarding boiler furnaces, methods of firing the different grades and kinds of coal and general boiler-room operation. If one makes a practice of visiting power plants, he will run across ways of doing things that are not generally known.

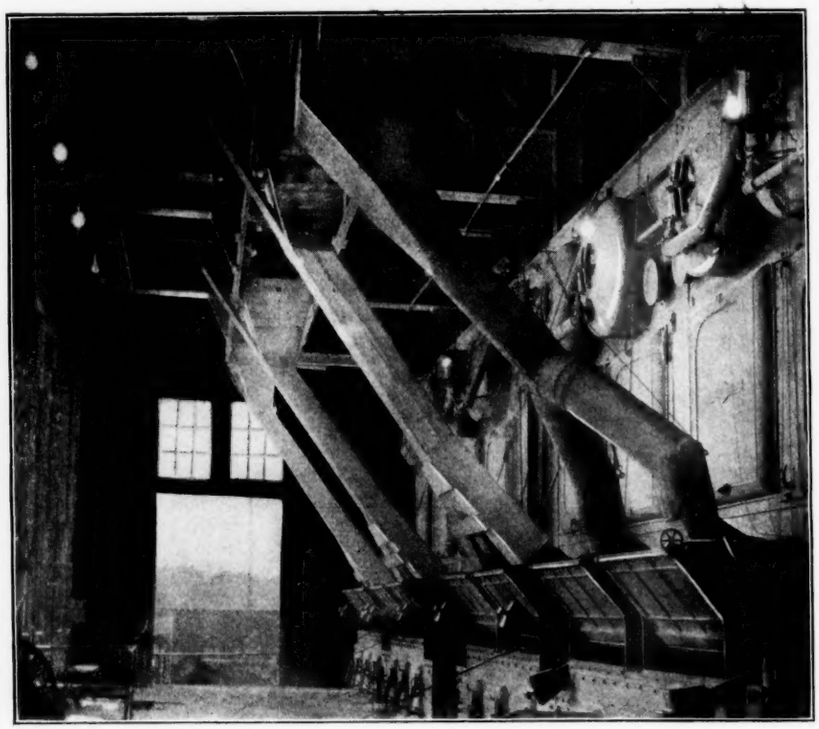


FIG. 1. HOPPERS OF THE HAND-FIRED BOILER FURNACES

If the question were asked as to what is the best method of firing anthracite that runs as fine as rice and no coarser than barley, the answer would probably be, to fire with a shovel light and often and keep the fire level. So far so good, but there is a better way and one that is easier on the men and requires fewer men in the boiler room. The method is not new, but the equipment required is so simple that it is a wonder that more boilers are not so fitted that the plan can be put into practice in burning the finer grades of anthracite.

In Fig. 1 is shown a partial view of the boiler room of the main plant of the Harrisburg Light and Power Co., Harrisburg, Penn. Four 300-hp. water-tube boilers are shown; there are also two 320-hp. boilers at the opposite end of the room, and two 320-hp. marine-type boilers are being put in. These boilers are all equipped with coal hoppers, as shown, although the furnaces are hand-fired—without using a shovel, however.

Here is the way it is done: The main fuel supply, which varies in size from rice to barley, is conveyed to the two coal bunkers above the firing aisle. Each has a capacity of 500 tons. In the view shown the coal is delivered to the furnace hoppers through the spouts without weighing. The hoppers on the other furnaces receive coal from the over-head bin through weighing scales, one serving two boilers. The other boilers will soon be equipped with weighing scales and the spouts to the hoppers discarded.

Under normal conditions the coal consumption of the plant is between 75 and 80 tons per day of 24 hr. Instead of shoveling this coal into the furnaces, it is pushed in with a light hoe. This is made possible by the employment of the McClave system of hopper and fuel control. Each hopper is fitted with two gates (see Fig. 3). Gate *A* swings on a pinion at each end, and its weight is partly counterbalanced by the arm and weight *B*. A second gate *C* closes the discharge outlet of the hoppers and is operated by the lever *D*. When it is desired to fire the furnace, the lever *D* is pulled down after throwing the hopper gate stop *E* to the outward position, giving the gate free movement. The amount of coal let down on the dead plate *F* is controlled by the fireman; about 150 lb. is the usual firing charge. If less is wanted, the gate *C* is not opened fully; if more is required, the gate is opened wide until the dead-plate space is filled. The gate *C* is closed when sufficient coal has been let down and is locked in its closed position by throwing the stop to the position shown in Fig. 3. Next the weight arm *B* is pulled down, opening the firing gate *A*. The fireman then takes the hoe shown in Fig. 2 and, resting the handle on the wearing shoe *G*, gives the coal a shove, spreading it in a thin layer over the fire bed. This operation is repeated about every 10 to 15 min. At frequent intervals the leveling tool

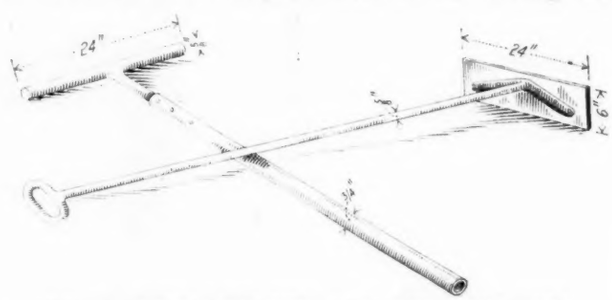


FIG. 2. SPREADING HOE AND LEVELING TOOL

is used to level off the fire, which with all small anthracite has a tendency to run in ridges. As the tools are light, the exertion exercised by the fireman is but slight. After the charge of coal has been pushed into the furnace,

the firing gate is closed and another charge of fuel can be let down from the hoppers.

Fires are cleaned about every 6 or 8 hours' run, depending on the quality of the coal. The grates are of the dumping type, no provision being made for shaking.

The fires are allowed to reach a thickness of about 15 in. before cleaning. In this plant the front half of the fire is cleaned first, the live coals being pushed back

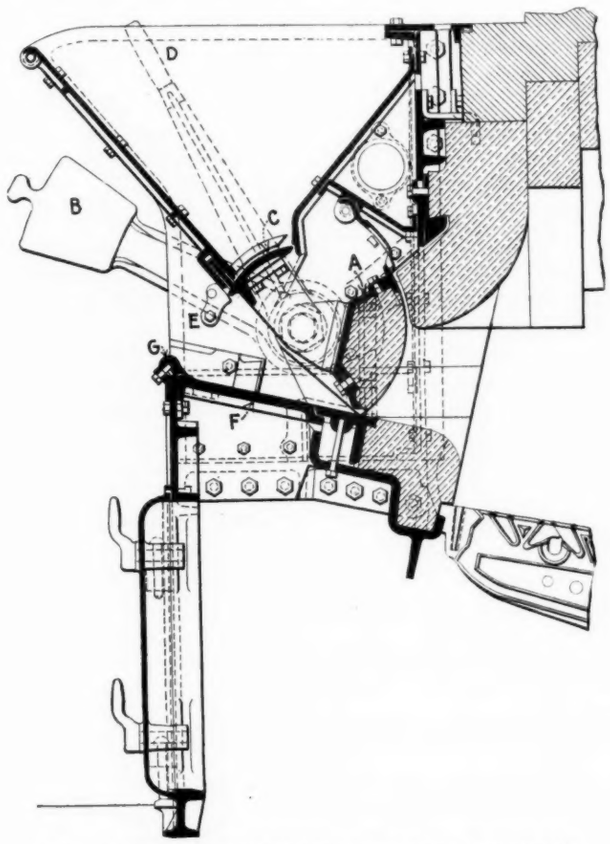


FIG. 3. SECTION THROUGH THE COAL HOPPERS

to the rear of the furnace and then the front three sections of the furnace grate are dumped, the ashes and clinkers dropping to an ashpit. Then the live coals are pulled forward upon the cleaned grates and the rear sections are dumped, after which the grate is evenly covered with the live coals and a thin sprinkling of fresh fuel is spread over them.

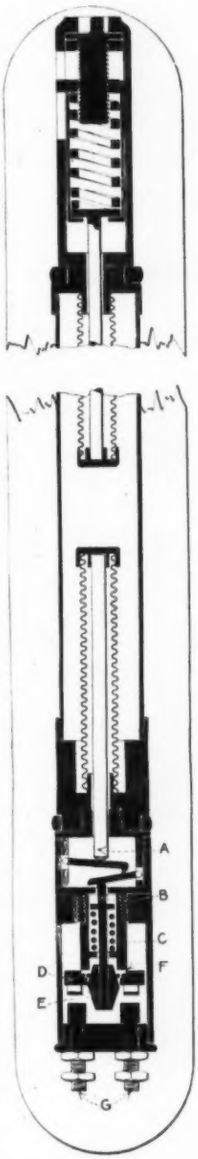
These dumping grates are made with 12 per cent. air space, and an air pressure of 0.10 in. is carried in the furnace. With the grade of fuel burned an evaporation of from 6 to 7 lb. of water per pound of coal as fired is obtained. The moisture content in the coal is about 9 per cent.; the ash runs about 17 per cent.

The men employed about the plant speak highly of the process of firing, and while the work is less laborious than with the ordinary method, the force for the plant is four men per day less than the number that would be required if the coal scoop were used.

The Power Gained by the Use of Pulleys is ascertained by multiplying the number of movable pulleys by 2. This rule applies only to the movable pulleys in the same block or when the parts of the rope which suspend the weight are parallel to each other. The mechanical advantage, however, that the pulley seems to possess in theory is considerably diminished in practice by the stiffness of the rope and the wheels friction.

Sarco Thermo Switch

The Sarco Co., Inc., Woolworth Building, New York City, is putting out a thermo electric switch. This new apparatus combines the expansion element of the ordinary Sarco regulator with a specially designed switch, as shown in the illustration. It is intended to furnish a means of operating electrically a switch for controlling a supply of current for heating, or to a motor for the distribution of hot air, or for any other purpose requiring the control of an electric circuit by temperature changes. The instrument has a calibrated scale from 58 to 78 deg. F. and is intended to operate the switch with a change of approximately 2 deg. in temperature. It can be constructed for any temperature up to 325 deg. F. The operating mechanism employs a brass tube filled with a heavy hydrocarbon oil, which on expansion compresses a spiral tube inserted in the oil. It is capable of withstanding pressures up to 2,000 lb., but a safety device is furnished in the form of a heavy steel spring in the regulating head. The expansion element pushes a rod out of the end of a tube by the expansion of a liquid, derived from increase in temperature. The movement is multiplied by levers. A motion is obtained sufficient to operate the snap switch with a very slight change in temperature. The instrument is shown in the "hot" position with the plunger extended. As it changes to the "cold" position, the rod *A* is slowly withdrawn into the tube and is followed up by the plunger *B*, which operation is based on the action of the spring *C*. The insulating member carrying the switch blade *D* is held in the position shown by the brass seat against which it rests, therefore the plunger head *E* is withdrawn slowly through this insulating member, expanding the spring *F*, which is an endless coil spring free to roll from one end to the other of the plunger head, carrying with it the insulating member which bears the switch contacts. As the plunger draws through this switch member, the spring *F* expands, and as the point of greatest diameter of the plunger head passes through the center of the spring *F*, the compression of the spring causes it to travel down the plunger head, bearing with it the insulating member, carrying the switch arms, which then hop over and make a contact with the terminal posts *G*, thus closing the circuit. This condition then obtains until the process reverses itself by application of a warmer temperature.



THERMO SWITCH

This switch can be operated on a 220-volt a.-c. or d.-c. circuit. Its action is quick and positive. The device will work with lamps burning on the system without causing a flicker.

Hydro-Electric Development in South America

By Ludwig W. Schmidt

SYNOPSIS—A review of the possibilities for hydro-electric development in South America. What is apparently the best way to finance these enterprises and what must be done by the American bankers and manufacturers to secure the greatest benefits not only for the promoters, but also for the country in which the enterprise is being carried on.

There is no other continent possessing physical features similar to those of South America. The gentle slope from west to east, beginning after the sharp descent of the Andes mountains, gives birth to several powerful streams. The Amazon and the La Plata are possibly the most remarkable river systems of the world, not only for their length, but also for the enormous water power they carry in their journey through the continent.

Another remarkable characteristic in this situation is that both of these river systems draw the larger part of their water from one center—a region west of the Cordilleras covered politically by parts of Peru, Bolivia and northwestern Brazil. Here in one region they have a rainfall of more than 80 in. and in another area more than 50 in. during the year. All other parts of South America have less rain, and the smaller river systems of southern Argentine receive their water entirely from the southern Andes. An exception only has to be made to certain small strips of country in southern Chile between the sea and the Andes which are very much favored by rain in consequence of their proximity to the sea.

The mountain barrier both in the east and the west and the necessity for all the larger streams to pass these barriers by falls has created conditions exceptionally favorable for hydro-electric development. Hydraulic engineers who have made a personal inspection of several of these rivers do not hesitate to state that many of these power sources are equal to those found in Switzerland and Norway, and have even called them the best locations for hydro-electric development in the world.

Hydro-electric enterprises today exist all over South America. In Brazil there are a number of companies operating hydro-electric power stations. The Rio de Janeiro Tramway Light and Power Co. has a large hydro-electric plant. This company at present is serving the City of Rio de Janeiro with light and power for industrial purposes and also for its tramway system. Its plant lies about 50 miles away and supplies 50,000 hp. Although this company derives most of the power needed by hydro-electric production, it also has a steam plant in Rio de Janeiro, which augments the hydro-electric installation.

The Companhia Brazileira de Energica Electrica in Rio also owns large rights securing 150,000 hp. The main turbines in this company's plant on the Piabanha River are of German construction and the generators were supplied by the General Electric Co. The same concern has a power house on the Itatinga Falls producing 60,000 hp. Brazil also has a great number of minor plants scattered throughout its territory.

One of the greatest hydro-electric enterprises that have been contemplated is the harnessing of the San Francisco River. Several schemes have been laid before the government to secure power from this source, but so far none of them seems to have found favor. One of the enterprises that had found support finally failed because it could not get the sanction of the President. In this case it was contemplated to use the hydro-electric power of the Paulo Affonso Falls. Estimates made seem to indicate a source of power in these which is considerably above that gained so far from any other important falls in the world.

The plan to use these falls requires an initial capital outlay of approximately $5,000,000, and it is contemplated to use at first a minimum capacity of 50,000 kw., which is to be increased in the following 25 years to 5,000,000 kw. This project if carried out would supply electric power to a large part of Brazil in a district that can be reached by ocean-going steamers.

Another important center for hydro-electric development is that big industrial and agricultural region centering around the mouth of the La Plata. A number of big rivers form there a convenient waterway into the interior of the continent, which, however, is interrupted by falls where the rivers break through the mountains.

Possibilities on the Uruguay River

Several propositions have been made to the governments interested dealing with the Uruguay River. The rapids of the Uruguay begin at Hervidero, about 17 miles south of Salto, and find their climax in a large fall at Salto itself. Without these falls the Uruguay might be very useful to shipping; as it is, larger boats can get only to Concordia. The scheme now in contemplation is to secure a greater length of the navigable depth of the river bed by erecting dams and sluices at Hervidero, San Isidro and Salto Grande. While part of the stored water will be most likely used for irrigation purposes, there will be more than sufficient left for hydro-electric purposes, and the erection of a large power station producing 70,000 hp. is part of the scheme. This station, which will be situated near Salto Grande, will have to distribute power over a considerable area. The project needs extensive work of all kinds, including the erection of a large dam and the building of canals. The cost has been estimated at about $28,000,000. A less ambitious project simply contemplates the building of a dam at a suitable place for irrigation purposes and for the production of the necessary electric power.

The important future development of hydro-electric enterprises in Argentina seems to be in the region round the City of Mendoza. This is the route taken by the trans-atlantic railway, and it is expected that considerable industrial life will spring up in the whole neighborhood, which seems to offer possibilities in several directions. In 1913 the government of the province approved of a scheme

which proposed the erection of a hydro-electric station on the Mendoza River. The estimated cost is $7,000,000. Unfortunately for the district, the work on this enterprise was interrupted during 1915 owing to a lawsuit between the company and the provincial government.

Turning to Chile, we find a number of minor and larger hydro-electric plants, mostly in the hands of individuals or private companies. Chile is favoring very much the erection of hydro-electric stations, and every year a number of new ones are added. Several of the larger mining companies have erected plants and not only utilize the power, but also sell it to others. During the last year several of these plants have been enlarged. Among the most prominent hydro-electric possibilities of Chile are those on the Aconcagua River. Several new schemes to use this power have been put forward recently, mostly supported by the City of Valparaiso. It is characteristic of Chile to favor small hydro-electric enterprises, a condition that also exists in Italy and Switzerland. This cutting up of the available power into small units has several advantages, but it also may have disadvantages owing to the fact that the available power is not always used economically. The government has recognized this fact and has appointed a commission to study the hydro-electric possibilities and also make a full investigation of the available power resources of the country. An endeavor will be made to reduce considerably the price of electrical power in Chile, which at the present time is fairly high.

Bolivia Lacks Development

Bolivia, which has a number of excellent sites for the erection of hydro-electric plants, has so far done little toward their development.

Peru has made good progress during recent years; her most prominent hydro-electrical enterprise is that of Chosico. This plant supplies Lima with power for light and industrial purposes, which is done by a 25-mile transmission line.

The South American industries in general are not developed uniformly. There are districts, mostly those in large cities, which have highly developed and modern industries, but there are other districts where industries are far apart and where the need for energy is not so great. However, it is possible to make hydro-electric enterprises pay even under this latter condition provided they are constructed to fit the demands of the district they have to serve. The necessity in many cases, as for instance in Peru and Chile, for constructing small plants, when run individually, has had a tendency to make the cost of current high. Prof. Don Arturo E. Salazar has pointed out that current in Argentina costs twenty times what it should if the available water resources were properly used. The cost of current in Valparaiso for industrial purposes was 14c. per kw.-hr. before the war.

The high price of coal is a vital question all over South America, and this is one of the reasons why, ultimately, hydro-electric development not only will pay its way, but will give good returns to the investor.

The industrial development of South America is not the result of a scientific building up of the industries, but rather that of convenience. The income of the country until quite recently has been derived from agricultural and mining enterprise. Unfortunately the best sites for creating hydro-electric power are not always most conveniently situated for distribution of energy to the consumer. The situation is most favorable in Chile, Peru and generally on the west coast. The narrow strip left here by the Andes has compelled industrial and agricultural settlement in that region where water for hydro-electric enterprises is near, and the question of transmitting power from the stations to the users offers little difficulty.

Best Sites Far from Coast

The best South American power sites east of the Andes are in the interior of the continent and necessitate transmission to localities far from the generating station, which makes the sale of power not only expensive but technically difficult. Industries sufficient to support large power stations exist only in the coastal districts, where large cities offer also a good market for electrical energy.

Nearly all the large recent projects propose not only the erection of power stations, but also the creation of cities in the immediate neighborhood of the power houses. This means that hydro-electric enterprises in South America, to be successful, cannot follow industrial or agricultural development, but must lead it.

Creating industrial centers is an undeniable risk for the investor. It means building a large plant and dams and creating a demand for the power the need for which while building is going on can only be estimated. Power stations can be built wherever there is a possibility of finding the necessary power; cities can be built only where there are transportation facilities. This at once limits the formation of big hydro-electric enterprises to sites within transmission distance of centers where there are transportation facilities, where industries can find raw materials and where they can find means of shipping their products. Several of these sites exist in South America, and they are mostly situated in such a way that they can make use of the waterways offered by the same rivers that also have to supply the energy.

Investments Follow Economic Development

Foreign investments incline to follow economic development rather than to lead it, at least with regard to power supply. To induce foreign investors to speculate in future values, it will be necessary to show them returns for their money larger than those which can be obtained under ordinary circumstances. Several of the South American governments have already acknowledged the fairness of this demand and have, in the case of railways, compensated investors in some way for their outlay by either paying part of the cost of the road or assisting the roads in some other way beneficial to the shareholders. It is very likely that a similar policy will have to be adopted to support hydro-electric development in those parts of South America where pioneer work will have to be done. Until then it seems fairly certain that foreign capital will follow the general rule and will confine itself to those enterprises from which sufficient returns can be expected when the plants are ready to supply current.

The creation of cities in connection with large hydro-electric enterprises in South America, however, has given rise to an additional problem that may become of great importance in the near future. The rivers forming the falls are frequently fed by river systems belonging to several governments. For instance, water rights on the

Uruguay necessitate the obtaining of concessions from Argentina, Brazil and Uruguay. All this of course makes it clear that the creation of a new industrial center in one country would not always be viewed with favor in the other. The carrying through of larger schemes is frequently hindered by political influence. However, where international questions do not interfere, as a rule no difficulties are met in securing the necessary concessions, provided the concession seeker is acceptable to the government and complies with the laws of the country.

In some cases, especially where the erection of smaller plants is contemplated, the free admission of machinery has been of assistance to the promoters, and the government in this way has helped the development of the industry.

Stations of medium size promise early returns to the investor and are more likely therefore to find support. A good many of these developments have been carried out and are still being carried out by native enterprise and investment. Also the large mining and industrial companies have found it to their advantage to enter the hydro-electric field.

For public-utility companies good chances exist for hydro-electric enterprises where it is possible to secure a market for the sale of electricity in the neighborhood and where the expenses of the enterprise can be kept inside a limited income. The fact that medium-sized enterprises are less likely to be drawn into the torrent of financial and economic depressions, still rather frequent in South America, is certainly in their favor.

Public Utilities Affected by War

The work on public utilities has come to a standstill since the outbreak of the war. South America had relied too much on the stability of the European money supply, and it was hard hit when the storm broke. There will be no real recovery in the Latin-American continent until Europe has returned to this field or until some other country has taken its place. It is to be hoped that the United States will fill the gap. Many difficulties are encountered in the financing of the big South American hydro-electrical enterprises. This, however, should not deter the bankers from entering this field. But the work is essentially one for the big financier or the international bank. Only those institutions have the means to study the propositions coming from South America, and only the banks are able to spread the financial responsibility in such a way so as to lighten the risk. In no other way than by investing heavily in South American enterprises can the American industries ever expect to get more than a passing hold on this market.

Hydro-electric investment, with the vast field it opens for general industrial enterprise, seems to be money well spent. It not only gives employment to American industries to supply building material, power machinery, etc., incident to the erection of such plants, but it also opens the way for further expansion in those districts whose industrial possibilities are opened by the power stations.

European banks before the war had fully recognized the necessity of supporting future development by investing heavily in public utilities. Railway investments, electric-light and power companies have proved to be good ventures for the banks of England and France. Also Germany, as a rule fully able to absorb any floating investments in her own industry, has seen the wisdom of financing South America. The result of this policy has been in all cases a preference for European goods which only in recent years has somewhat changed in favor of American supplies.

South America offers a fair market for hydro-electric power machinery. German turbines have found much favor, but English and American electrical machinery has also been used. This country has been holding practically a monopoly in supplying certain machines. Unfortunately it is extremely difficult to obtain exact data on the actual demand for water-power machines in the South American markets during past years. None of the nations in question is sufficiently thorough in its statistical recording system to register the imports of such machinery. Only Germany has recorded for several years the exports of water-power machines to South America, and it is not uninteresting to see the extent of her business as shown in the following statistics.

Equipment of German Make

The value of German water-power machinery sold in the South American markets from 1909 to 1913 inclusive is as follows: In 1909, $41,500; 1910, $133,250; 1911, $250,000; 1912, $279,250; 1913, $339,000. These figures do not tell very much; they show, however, that there has been an increasing demand in South America for water-power machines from Germany, at least, and it is most likely that England and this country as well have sent such machinery there. Statistics also indicate a good demand for the heaviest type of dynamos and other electrical machinery generally used for this kind of work.

The war has interrupted not only the capital supply, but also the regular supply of industrial goods customarily bought from Europe. It is said that South America thrown on her own industrial resources has tried to make up for the loss and begun to manufacture certain articles formerly bought abroad. The continent, given sufficient capital to carry out local enterprises, will quickly develop its industries. This will bring an increase in the demand for power of all kinds, and it will give hydro-electric development its big chance. The possibilities are that after the war a period of rapid growth of the hydro-electric industry will begin, which under the present circumstances will have to be sustained with machinery coming from this country.

Outlook After the War

Hydro-electric development after the war will be of two kinds. It will be the exploitation of the large schemes entailing the expense of millions of dollars, as the development of the power of the Uruguay, or it will be of the smaller and medium kind as offered by the many small rivers of Chile with a limited field of distribution. Each kind demands different treatment. While the first will have to be left entirely in the hands of banking houses and while the American water-power-machinery manufacturers in this case will not be able to do anything else than follow the lead of large capital, the second kind can be handled by the manufacturers individually.

Millions of dollars finally will be spent in these medium-sized enterprises. The money for them will be supplied mainly by local investors, and also American capital

may have to assist in this development. Here is an opportunity for the newly created foreign agencies of the American banks to do a real service to the American manufacturer by watching these opportunities and informing manufacturers about them when they arise. It will be necessary to find out whether these new enterprises deserve the credit they will have to ask from the manufacturer, so that the latter will be able to inform himself at an American bank. Also the banks will have to facilitate the credit by carrying the paper of these firms. There is no doubt that any outlay made in this direction will pay. It is not the cheapness and the inferior quality which has introduced European goods into the South American markets; it is the system employed by European manufacturers which has brought the trade. This holds good for engineering enterprises as well as for any other.

The large American electrical companies as a rule are well represented in the South American markets and in this way are able to connect the consumer with the manufacturer. They will be able to inform themselves about contemplated stations and possibly will be best able to advise the promoters what to buy. It is, however, the individual effort of each manufacturer that in the end brings the results, and it seems that in this respect the American manufacturer has still to learn from the European.

European manufacturers of water-power machinery used to advertise in the native press before the war, a custom that should be followed by the American manufacturers as it frequently will find an interested party not to be reached by any other means. Also the power of the American engineering press as a means of communicating with the prospective buyer should not be underestimated. Technical magazines are always consulted in such cases before orders are finally placed or when estimates are demanded.

Price lists in Spanish and Portuguese will be as much a necessity for the American manufacturer as they have proved to be for the European, and the American in this way should learn from the experience of the former.

To secure the best results it will be necessary to do some of our own developing. This means not only to sell machines where they are asked for, but also to study the market and do educational work among the possible users of energy in the neighborhood; in fact, to work up the proposition. This, however, can be done only by local effort, and it is just this sort of work that will finally pay the promoter. The income from the power supply of electric stations can be increased by the sale and the installation of all kinds of electrical devices. It is doubtful whether exporters of electrical goods at the present time would be far-sighted enough to give sufficient support to such enterprises, but it is certain that this will be the best way of securing the market.

The investigations for the discovery and charting of all available water power which are being carried on now by most of the South American governments will greatly assist future hydro-electric development. To get the full benefit of this activity it would be well to study conditions in Norway, Sweden, Switzerland and at the southern slopes of the Alps in Italy, where many hints may be obtained for the carrying out of small hydro-electric installations in South America.

Synchronous Converters--I

By F. A. Annett and Gordon Fox

SYNOPSIS—This article is the first installment of a series of three on rotary converters and explains the purpose of the machine, the different ways in which it may be used, its operation and the relation between the direct-current values at the commutator and the alternating current and voltage at the collector rings.

As the conductors on the armature of an electric generator pass under alternate north and south poles, there is generated in them an alternating voltage. By means of a commutator a direct current is collected from ever-changing sets of coils having a fixed relation to the polepieces. A rotary converter is similar to the direct-current generator in that alternating current flowing in the armature conductors is collected as direct current through the use of a commutator. In the direct-current generator, however, the alternating voltage is generated in the armature conductors, whereas in the rotary converter the alternating voltage is introduced into the armature conductors through slip rings which connect with taps to the armature windings. The taps to the armature windings are so located with respect to the polepieces that their phase relation corresponds with that of the external circuit. Thus in a single-phase rotary converter the taps are spaced 180 electrical degrees, in a three-phase 120 electrical degrees and in a six-phase 60 electrical degrees apart.

Fig. 1 shows the armature of a large rotary converter which is the same as that for a large direct-current generator with rings tapped into the armature winding on the opposite end of the armature shaft from the commutator. The rotary converter may be used for any purpose for which a dynamo electrical machine is used. If direct current is supplied to the commutator, it will run as a direct-current motor and as such may be used to do mechanical work. Supplying alternating current to the armature through the collector rings, it will then run as a synchronous motor, or synchronous condenser, and may be used to do mechanical work, for power-factor correction, or a combination of both.

Driving the machine from some source of mechanical power, it may then be used as a direct-current generator, an alternating-current generator or for both. That is, alternating current may be taken from the collector rings and direct current from the commutator at the same time. When used for the latter purpose, the machine is known as a double-current generator; such installations have been made. The low-voltage direct current was used for near-at-hand distribution, the alternating current stepped up through transformers and transmitted to the

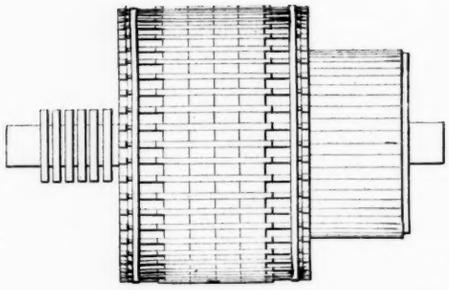


FIG.1

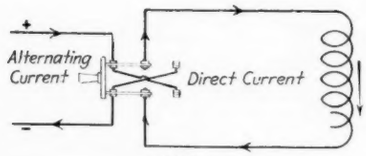


FIG.2

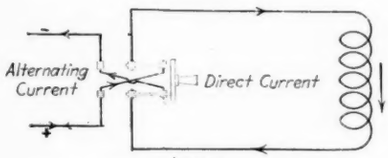


FIG.3

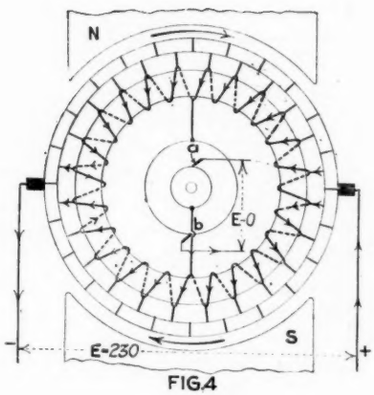


FIG.4

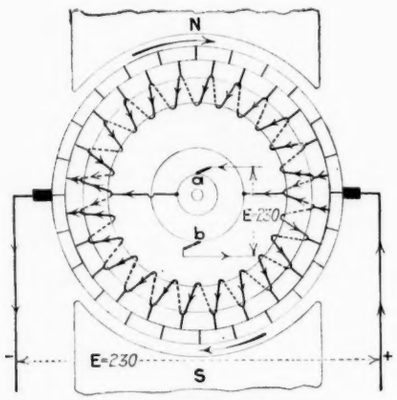


FIG.5

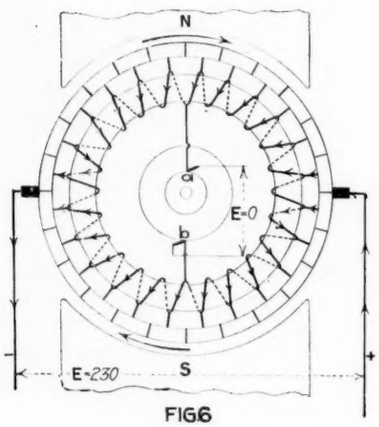


FIG6

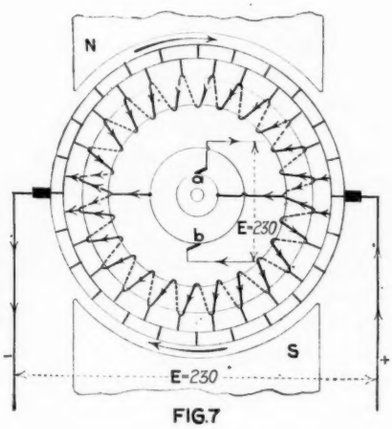


FIG.7

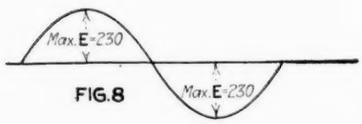


FIG.8

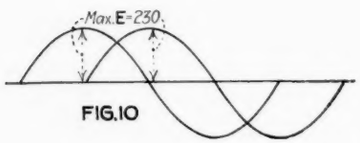


FIG.10

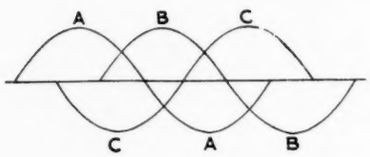


FIG.12

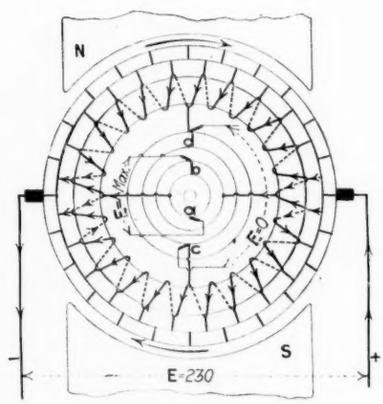


FIG.9

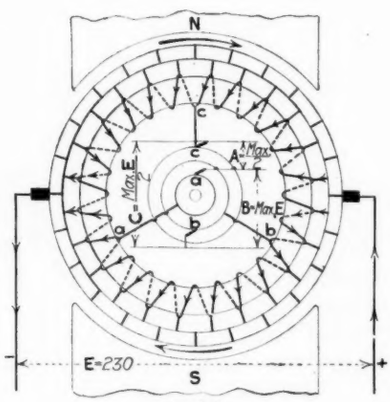


FIG.11

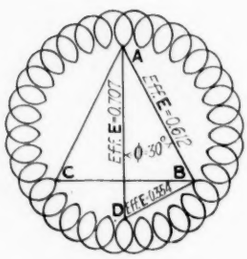


FIG.13

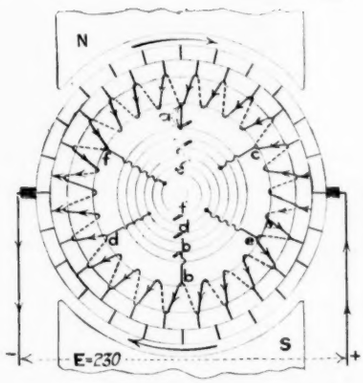


FIG.14

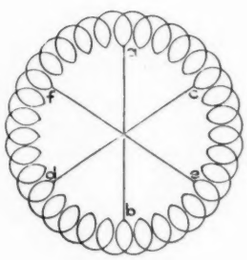


FIG.15

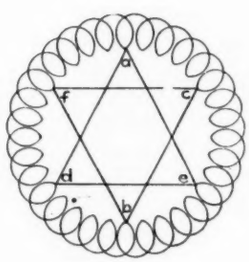


FIG.16

FIGS. 1 TO 16. EXPLAINING THE OPERATION OF THE DIFFERENT TYPES OF ROTARY CONVERTERS

outlying districts, where it was stepped down and distributed as low-voltage alternating current.

When direct current is supplied to the commutator, it will run as a direct-current motor and supplies alternating current at the collector ring. As such the machine is known as an inverted rotary converter. The primary purpose of this machine is to convert alternating into direct current; in doing so, low-voltage alternating current is supplied to the collector ring and is converted into direct current at the commutator. When used for the latter purpose, it is called a rotary converter. Nearly all rotary converters are used for this purpose, only a very small part of 1 per cent. of the total capacity are used as double-current generators or for converting direct current into alternating.

Use of Double-Throw Double-Pole Switch

A double-throw double-pole switch may be used to change an alternating current into a direct current or vice versa, as shown in Figs. 2 and 3. Throwing the switch over every time the alternating current reverses in the circuit will deliver a direct current to the load, as indicated by the arrow-head. For various reasons the scheme is not practical except in small rectifiers; nevertheless, it is what gradually takes place between the collector ring and the commutator of a rotary converter, as will be seen by the following:

In Fig. 4 is shown a ring armature arranged so that it can revolve between the polepieces *N* and *S*. A current flowing through the armature from the commutator, as indicated, will cause it to rotate in the direction of the curved arrow; that is, the machine will operate as a direct-current motor and the counter electromotive force generated in the armature will be almost equal to the applied voltage. By connecting two collector rings to opposite points in the armature winding, as shown, a varying potential will be obtained across the brushes *a* and *b*. At the position shown the voltage across the collector ring will be zero because both points in the armature that the collector rings connect to are located on the axis of the magnetic field.

When the armature has revolved through 90 deg., as indicated in Fig. 5, the collector rings will connect direct to the brushes on the commutator; therefore, the voltage across them will be the same as that of the direct-current circuit; namely, 230 volts. The direction of the e.m.f. at the collector rings, and consequently the current for this position will be as shown by the arrow-head. Fig. 6 shows the position of the armature when it has revolved 90 deg. from the position in Fig. 5, and the potential across the collector rings will again be 0, for the reason explained in Fig. 4. Turning the armature through another 90-deg. angle will bring it into the position shown in Fig. 7, and the potential between the collector rings will again be equal to the direct-current voltage. This time, however, the direction of the potential at the collector rings will be opposite to that shown in Fig. 5. When the armature has revolved 90 deg. from the position shown in Fig. 7, it will be again located as in Fig. 4 and a zero potential will again be impressed upon the collector rings.

From the foregoing it will be seen that in one revolution of the armature the voltage at the collector rings of a two-pole rotary converter increases from zero in Fig. 4 to a maximum in Fig. 5, decreases to zero again in Fig. 6, reverses and builds up to maximum in Fig. 7 and back to zero on the last quarter of the revolution. In other words, an alternating electromotive force is obtained at the collector rings and may be represented by the sine curve, Fig. 8. The maximum of the curve will equal the direct-current voltage applied to the commutator, or in this case 230 volts.

The effective value (*E* or *I*) of a sine curve of electromotive force or current is equal to the maximum value of the curve multiplied by 0.707. The maximum value of the curve for the single-phase rotary converter shown in Figs. 4 to 7 is 230 volts. Therefore the effective value of the e.m.f., or voltmeter reading at the collector rings, equals $230 \times 0.707 = 162.6$ volts.

The reverse of what has been shown is also true; if alternating current is supplied to the collector rings, the machine will run as a synchronous motor and supply a direct current at the commutator. The value of the direct-current voltage will equal the effective alternating-current voltage divided by 0.707. In the case at hand $162.6 \div 0.707 = 230$ volts.

In a two-pole two-phase rotary converter four collector rings are tapped into the back of the armature winding, as shown in Fig. 9. In the position indicated in the figure, a maximum electromotive force will be produced between rings *a* and *b*, and zero between rings *c* and *d*, as was explained in Figs. 5 and 4, respectively. This is the condition that exists in a two-phase circuit—two equal electromotive forces with one of them at a maximum when the other is at zero. The curves, Fig. 10, show the relation between the voltages or currents in a two-phase circuit. Since the collector rings of each phase of a two-phase machine tap the armature winding on the diameter as do the collector rings of a single-phase, it is obvious that the single-phase voltage ratio will exist between the direct- and the alternating-current circuits of the former.

Two-Pole Three-Phase Converter

In Fig. 11 is shown a two-pole three-phase rotary converter. Here three collector rings are used and tapped into the armature winding 120 deg. apart. The point where the highest voltage will be obtained between the collector rings will be where a section of the winding connected between two collector rings is directly under one of the polepieces, as the section connected between rings *a* and *b* in the figure. The pressure between collector rings *a* and *c*, likewise between *b* and *c*, for the position in the figure will be only 0.5 that between *a* and *b*. This is readily understood by considering the direction of the electromotive force in sections *ac* and *bc* of the winding. The voltage in these sections below opposes that above the horizontal axis, therefore it will neutralize the electromotive force in a similar section above this axis, as concerns the voltage between the collector rings.

The section that is effective in producing pressure between collector rings *a* and *c* and *b* and *c* is only half as great as that between *a* and *b*. At the instant shown the voltage of *A* and *C* will be in the same direction but opposite to that in *B*. This is just the condition in a three-phase circuit, three equal electromotive forces, having such a relation to one another that when one is at a maximum value the other two are at 0.5 maximum and opposite to the first, as indicated in Fig. 12, which shows the three electromotive-force or current waves of a three-phase circuit.

In Fig. 11 it is obvious that the maximum voltage, consequently the effective electromotive force between the collector rings, will at no position of the armature be equal to that of the single-phase or two-phase machine. In the single-phase and two-phase machines the maximum voltage was measured across 180 deg. of the winding, whereas in the three-phase it is measured across only 120 deg. Therefore the ratio 0.707 between the direct-current and the alternating-current electromotive force of a single-phase or a two-phase machine is not correct for a three-phase.

The ratio between the direct-current and the alternating-current voltage on a three-phase rotary converter is explained in Fig. 13. It can be shown that if the diameter of the armature is allowed to represent to scale the effective electromotive force across the armature winding on the alternating-current side, a chord drawn from one end of this diameter will represent to scale the effective electromotive force across the section of the winding included between the ends of the cord. Thus in Fig. 13 if the diameter AD represents to scale the effective electromotive force on the alternating-current side of a single-phase machine, a line drawn from A to a point B in the winding 120 deg. from A will represent to scale the effective electromotive force across this section of the winding. It has been shown that the maximum electromotive force on the alternating-current side of a single-phase rotary converter is that across the diameter of the winding and equals the direct-current voltage, also that the effective electromotive force equals the maximum $E \times 0.707$. In other words the effective alternating-current voltage equals the direct-current voltage multiplied by 0.707.

In Fig. 13 if the direct-current voltage is represented by unity, the effective alternating-current voltage will be represented by 0.707, as shown in the figure. Drawing a line from B to D forms the right triangle ABD. $AB = AD\cos.\phi$; $\phi = 30$ deg. and cos. 30 deg. $= 0.866$. Therefore $AB = 0.707 \times 0.866 = 0.612$. Hence the voltage at the collector rings of a three-phase rotary converter equals that at the commutator multiplied by 0.612, or in Fig. 11, $230 \times 0.612 = 141$ volts.

As was shown for the single-phase machine, the inverse of the foregoing is true; namely, if 141-volt three-phase alternating current is applied to the collector rings, the direct-current voltage at the commutator will equal the voltage at the collector rings divided by 0.612, or $141 \div 0.612 = 230$ volts.

Most large converters are six-phase machines. Fig. 14 shows a two-pole six-phase rotary converter. It will be seen that six collector rings tap into six equidistant points on the armature windings. It is possible to get three different voltages from this connection; namely, single-phase, three-phase and six-phase. If the voltage is measured between brushes a and b, c and d, and e and f, in each case it will be across the diameter of the windings, therefore the single-phase voltage will be obtained. It is usually referred to as the diametrical voltage and is shown somewhat simplified in Fig. 15. When taken across points a and e, a and d, d and e, b and c, b and f, and c and f, the voltage will be measured across points 120 deg. apart on the windings, therefore will give a three-phase voltage. Fig. 16 shows that the readings are taken from what forms the angle of two equilateral triangles, or a double delta, which is what this connection is known as.

Taking the reading between brushes a and c, c and e, e and b, b and d, d and f, and f and a, in each case the voltage is measured between points only 60 deg. apart on the winding, therefore less than that of the three-phase voltage. Referring to Fig. 13, it will be seen that the chord BD embraces 60 deg. of the winding, consequently represents to scale the effective six-phase voltage. $BD = AD$ sine ϕ. $\phi = 30$ deg. and sine 30 deg. $= 0.5$. Hence $BD = 0.707 \times 0.5 = 0.354$ approximately. That is, the ratio between the commutator and the adjacent collector-ring taps on a six-phase machine is 0.354. In this case the alternating voltage equals $230 \times 0.354 = 81.4$ volts. This latter connection is seldom used and consequently is of little importance.

The values for the voltage and current at the commutator and collector rings of the different types of rotary converters may be found as follows, where E_d = the direct-current voltage, E_a = the alternating-current voltage, I_d = the value of the direct current and I_a the value of the alternating current in amperes per terminal:

For a single-phase rotary converter $E_d = \frac{E_a}{0.707}$, $E_a = E_d \times 0.707$, $I_d = I_a \times 0.707$ and $I_a = \frac{I_d}{0.707}$.

For a two-phase machine E_d and E_a will be the same as for a single-phase. Since there are two circuits on the alternating-current side instead of one, the current per terminal will be only 0.5 that of the single-phase machine, or $I_a = \frac{I_d}{1.414}$ and $I_d = I_a \times 1.414$.

In a three-phase rotary converter $E_d = \frac{E_a}{0.612}$, $E_a = E_d \times 0.612$, $I_d = \frac{I_a}{0.943}$ and $I_a = I_d \times 0.943$.

For a six-phase double-delta-connected machine the voltage is the same as a three-phase. The current $I_d = \frac{I_a}{0.472}$ and $I_a = I_d \times 0.472$.

In a diametrically connected six-phase machine the voltage is the same as a single-phase. The current $I_d = \frac{I_a}{0.472}$ and $I_a = I_d \times 0.472$.

The foregoing voltage and current ratios are based on the theoretical output of the machine; the actual values will vary from 2 to 4 per cent. from these.

Saving Effected by Economizer

By R. von Fabrice

The problems of successful and economical power generation for the manufacturing plant as well as the central station have developed tendencies toward higher over-all thermal efficiencies, and to meet these demands more efficient apparatus has been produced by the manufacturers.

The improvements in the thermal efficiencies of prime movers have been remakable these last ten or fifteen years, while the economy of the boiler has remained practically at a standstill.

It is not only necessary to have efficient prime movers, but the greatest possible number of B.t.u. must be absorbed from the coal, as the fuel bill is the largest part of the operating expense in any power plant.

Under modern operating conditions, in the largest stations in this country, it is not uncommon practice to

force the boilers from 100 to 250 or 300 per cent. of normal rating at peak loads on the station, and the newest plants are designed to operate the boilers at 100 per cent. above rating at normal load. Such being the case, it is easy to see that large quantities of heat pass through the uptakes of the boilers. A great saving can be made by absorbing the B.t.u. from the flue gases.

Boiler makers have increased the heating surface in the boilers to the economical limit, the proportion of heating surface to grate area being larger, and yet the temperature of the gases is excessive, resulting in a large thermal loss to the station. This problem has become so acute that the later stations have installed economizers between the uptakes of the boilers and the stack, with good results.

Economizer installation did not get much encouragement in this country until recent years, and this is due largely to three factors: First, the cheapness of the fuel; second, the size of the prime movers; and third, the inability to force boilers of large capacities by means of the then prevailing firing methods employed.

Forcing Produces High Temperatures

With the use of the underfeed stoker, forced and induced draft, it was found that boilers could be safely forced to 300 per cent. of rating with the resulting factor of high flue-gas temperatures. This meant a great loss of B.t.u. in the flue gases, so the questions at once arose: Why force boilers to such excessive ratings? Why not install more boilers and operate more sanely? These questions are obviously simple. It is not only boiler investment, but cost of building, auxiliaries such as stokers, stacks, flues, maintenance, insurance, interest and operating costs that enter the problem, and these were the items that brought about forced firing, with economizers, in the most modern power stations.

Much adverse criticism has been made relative to economizer installations. Common faults were high operating cost, difficulty in keeping clean, large repair items, trouble with leaky joints, etc.

The keeping-clean problem has been solved. The introduction of a feed-water heater to heat the water to 180 or 200 deg. F. before it enters the economizer eliminated sweating and the consequent sticking of soot to the tubes, so that it is easy for proper soot-blowing devices to remove the dry soot. Improved materials and better designs have reduced the repair item.

With the installation of economizers additional heating surface is obtained, and the question at once arises, Why not increase the square feet of boiler-heating surface per square foot of grate area?

In modern practice boilers generate steam at 225 lb. gage pressure, which, when saturated, has a temperature of approximately 397 deg. F., and it is not uncommon practice to cool the gases to 300 deg. F. in an economizer. Now to fire a boiler to get a flue-gas temperature of 300 deg. F. at the uptake would be equivalent to generating steam at some pressure less than 52 lb. gage, which would be most inefficient and impractical. Boilers have not been designed to reduce the flue-gas temperature much below 600 deg. F. at 150 per cent. excess boiler rating with underfeed stokers.

The advantages of economizer installations can be determined by a consideration of the following items: Cost of fuel on a B.t.u. basis, cost of installation, temperature of flue gases at uptake, temperature of flue gases leaving economizer, and pounds of air per pound of fuel.

Assume 14 lb. of air per pound of coal, making approximately 15 lb. of gas per pound of fuel, also a flue-gas temperature of 600 deg. F. leaving the boiler and 300 deg. F. leaving the economizer, making a difference in temperature of 300 deg. F. With the specific heat of the gases 0.22, the 300 deg. difference in temperature would mean $0.22 \times 300 = 66$ B.t.u. per pound of gas, or $15 \times 66 = 990$ B.t.u. per pound of coal. This represents $\frac{990}{14{,}000} = 7.07$ per cent. of the fuel. The annual saving for a 1,200-hp. boiler at 200 per cent. of rating, burning 3 lb. of coal per boiler horsepower per hour, the coal costing $3 a ton (2,240 lb.) delivered on the grate, would be figured as follows:

$$1{,}200 \times 3 = 3{,}600 \times 2 = 7{,}200 \text{ lb. of coal per hour}$$
$$300 \text{ days at } 24 \text{ hr.} = 7{,}200 \text{ hr. per year}$$
$$7{,}200 \times 7{,}200 = 51{,}840{,}000 \text{ lb. of coal per year}$$
$$\frac{51{,}840{,}000}{2{,}240} = 23{,}143 \text{ tons per year}$$
$$\text{Saving} = 23{,}143 \times 0.0707 = 1{,}636 \text{ tons}$$
$$1{,}636 \times \$3 = \$4{,}908$$

The approximate cost of the economizer including settings and extra flues would be $7 per boiler horsepower installed, making a total of $8,400 for a 1,200-hp. boiler. The various charges against the installation may be summed up as follows:

Taxes, interest and insurance, 12 per cent.	$1,008.00
Operating expenses, 4 per cent.	336.00
Depreciation, based on eight years' life and scrap value of 5 per cent., or $420	997.50
Total charge per year	$2,341.50

Deducting the total charge from the saving gives $4,908 — $2,341.50 = $2,566.50 over and above the required charges of interest, taxation, insurance, depreciation and operation, to be considered as a profit, netting 30.55 per cent. annually on the investment.

The illustration cited may be applied to hundreds of cases, and it is up to the designer or consulting engineer to make careful analysis of the problem before deciding for or against an economizer installation.

There is a large and varied field for the successful installation of economizers in isolated plants of manufacturing establishments, as well as in the boiler houses of electrically operated railroads and light and power companies.

The tendency nowadays is to increase the boiler output due to the installation of new and larger generating units in the existing turbine and engine rooms, and in many cases this result can most successfully be accomplished by the judicial installation of economizers which will increase the thermal efficiency of the steam-generating equipment at nominal cost and result in a handsome annual net return to the owner.

[In assuming 14 lb. of air per pound of coal, the author has taken a figure seldom reached in practice. More excess air, say 16 or 18 lb. per pound of coal, simply means that the possibility of saving by the installation of an economizer is proportionally increased.—Editor.]

Lighting Up After a Boiler Has Been Out of Use for some time should always be done by the regular boiler attendant, because the opening up of a boiler—its overhauling, cleaning and filling—is associated with so many possibilities of which a night watchman is unaware, that he should not be intrusted with the duty of getting up steam for the first time. Pipe and manhole joints may have been broken and not made good again or not tightly screwed up; safety valves, cocks and valves may have been overhauled and not properly put together again.—C. E. Stromeyer.

Clinkering of Bituminous Coal--II*

By F. C. Hubley†

SYNOPSIS—Investigation shows that in relation to fusing, bituminous coal ash may be divided into three classes; namely, long range, short range and variable range. (Range refers to temperature of fusion.) Several curves showing the fusing characteristics of different ash appear in the article.

In predicting the probable clinkering action of a coal in a boiler fire, two general factors obtained from the laboratory fusion test must be considered: The length of the softening range and its position on the temperature scale in relation to the working temperature range of the boiler fire; the physical nature of the fusion throughout the softening range.

From a study of a number of the curves produced with the fusionmeter, in connection with results obtained in

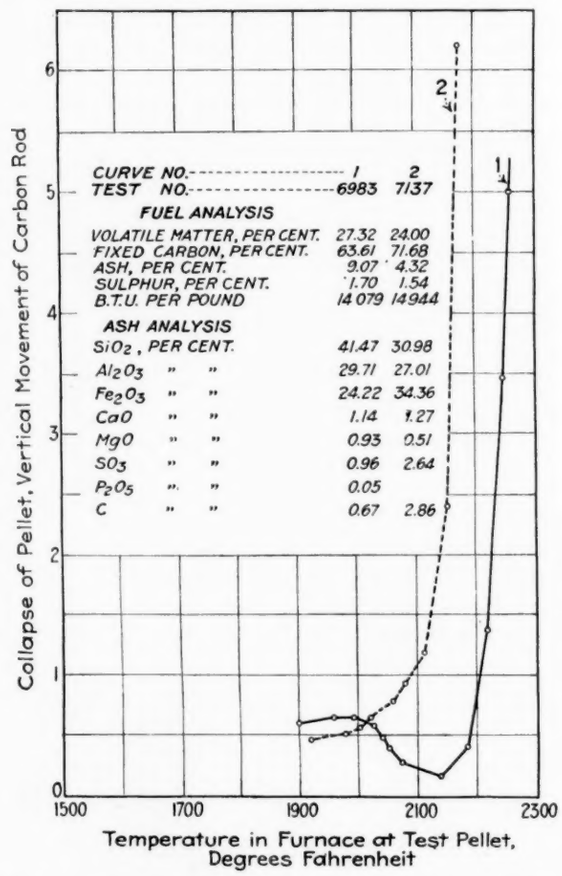

CURVE NO. 1 2
TEST NO. 6983 7137
FUEL ANALYSIS
VOLATILE MATTER, PER CENT. 27.32 24.00
FIXED CARBON, PER CENT. 63.61 71.68
ASH, PER CENT. 9.07 4.32
SULPHUR, PER CENT. 1.70 1.54
B.T.U. PER POUND 14 079 14944
ASH ANALYSIS
SiO2, PER CENT. 41.47 30.98
Al2O3 " " 29.71 27.01
Fe2O3 " " 24.22 34.36
CaO " " 1.14 1.27
MgO " " 0.93 0.51
SO3 " " 0.96 2.64
P2O5 " " 0.05
C " " 0.67 2.86
Collapse of Pellet, Vertical Movement of Carbon Rod
Temperature in Furnace at Test Pellet, Degrees Fahrenheit

FIG. 5. ASH HAVING VERY SHORT FUSING RANGE

the boiler room, bituminous-coal ashes appear to be divided generally into three classes, as regards fusion:

First—A longe-range ash, producing a rather steep curve throughout most of its softening range and with no particular final temperature at which it becomes very soft. This ash is somewhat represented by curves 3 and 4 in Fig. 7, but more particularly by curves 2 and 3 in Fig. 10. This high-viscosity type, provided the softening range coincides approximately with the working-temperature range of the boiler fire, generally produces the greatest losses from clinker formation. The formation is always of a tough and gummy nature and in arching over the

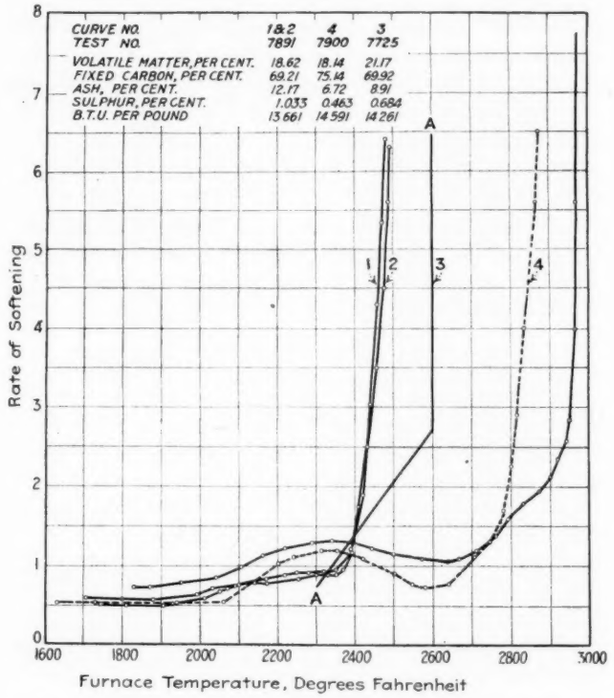

CURVE NO. 1&2 4 3
TEST NO. 7891 7900 7725
VOLATILE MATTER, PER CENT. 18.62 18.14 21.17
FIXED CARBON, PER CENT. 69.21 75.14 69.92
ASH, PER CENT. 12.17 6.72 8.91
SULPHUR, PER CENT. 1.033 0.463 0.684
B.T.U. PER POUND 13 661 14 591 14 261
Rate of Softening
Furnace Temperature, Degrees Fahrenheit

FIG. 6. SHORT FUSING RANGE, ASH SHOWN BY CURVES 1 AND 2

dumping grate of a stoker, between the bridge-wall and main grate, makes cleaning of the fires most difficult.

Second—A very short-range ash, melting suddenly to great fluidity, illustrated by curves 1 and 2, Fig. 6, and curve 2, Fig. 5. It gives trouble only when its final melting point is reached and passed in the boiler fuel bed; consequently the boiler-room reports on a coal of this nature will be more inconsistent than when burning ash of the long-range character, although the clinker formation is as detrimental to boiler operation as the former.

Third—A variable-range ash which sometimes reaches great fluidity at the final temperature, but which expands to a greater or lesser extent just previous to final softening. The clinker is consequently brittle, or "rotten," and if formed at a temperature not too much below the average fuel-bed temperature, will give little trouble in removal, although causing a somewhat dirty fire. This type of fusion is indicated by a dip in the curve just previous to final softening, as in curve No. 1, Fig. 5, curves 3 and 4, Fig. 6, and those in Figs. 8 and 9. Ash of this character appeared to be in the majority among those tested.

These three types of ash fusion are best represented in the shape of the curves by the fusion tests on red oxide of iron, ferrous sulphide and calcium sulphate in Fig. 11.

The majority of the coals represented by the curves in Figs. 5, 6, 7, 8 and 9 were tested under Rust boilers with Taylor stokers operating from rating to 180 per

*Article I appeared in the Oct. 10 issue.

†Engineer, American Bridge Co.

rent. of rating, steam being supplied to rolling-mill engines. From considerable observation with the Fery radiation pyrometer, the fuel-bed temperature limits appeared to be 2,250 deg. F. at rating to 2,750 deg. F. at the high load. The reports from the boiler house on the behavior of these coals are reproduced in the following paragraphs with as much fidelity as possible. While the fluctuating boiler load or the "dull burning" quality of the coal at times makes the link between boiler-room results and laboratory results somewhat vague in nature, most of the evidence is of a positive nature.

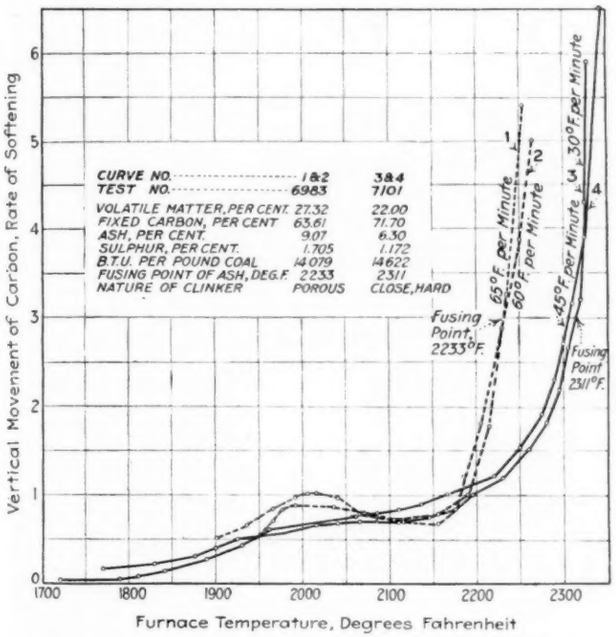

Vertical Movement of Carbon, Rate of Softening
Furnace Temperature, Degrees Fahrenheit
CURVE NO. 1&2 3&4
TEST NO. 6983 7101
VOLATILE MATTER, PER CENT. 27.32 22.00
FIXED CARBON, PER CENT 63.61 71.70
ASH, PER CENT. 9.07 6.30
SULPHUR, PER CENT. 1.705 1.172
B.T.U. PER POUND COAL 14079 14622
FUSING POINT OF ASH, DEG.F 2233 2311
NATURE OF CLINKER POROUS CLOSE, HARD
65°F. per Minute
60°F. per Minute
45°F. per Minute & 30°F per Minute
Fusing Point 2233°F.
Fusing Point 2311°F.

FIG. 7. LONG-RANGE ASH, PARTICULARLY CURVES 3 AND 4

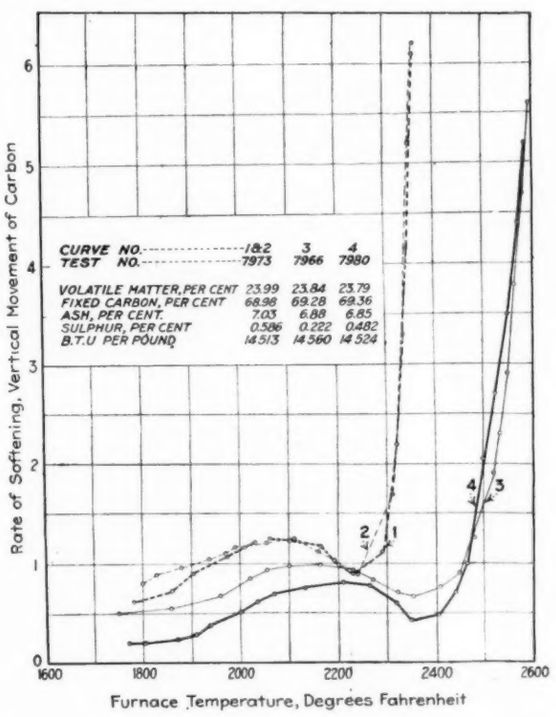

Rate of Softening, Vertical Movement of Carbon
Furnace Temperature, Degrees Fahrenheit
CURVE NO. 1&2 3 4
TEST NO. 7973 7966 7980
VOLATILE MATTER, PER CENT 23.99 23.84 23.79
FIXED CARBON, PER CENT 68.98 69.28 69.36
ASH, PER CENT. 7.03 6.88 6.85
SULPHUR, PER CENT 0.586 0.222 0.482
B.T.U PER POUND 14513 14560 14524

FIG. 8. CURVES REPRESENT AN ASH HAVING VARIABLE FUSING RANGE

The reports from the boiler room under regular operating conditions follow:

Fig. 5, curve No. 2: "A very undesirable fuel on account of the radical clinkering quality of the ash. A tough gummy clinker formed, requiring from 20 to 45 min. to remove at fire-cleaning periods." Curve No. 1: "This coal burned freely, with a long flame, the only undesirable point being the formation of large clinkers, which did not, however, cause a serious amount of trouble."

Fig. 6, curves 1 and 2: "Proved to be unsatisfactory; it clinkered severely when the fire was forced. One clean-

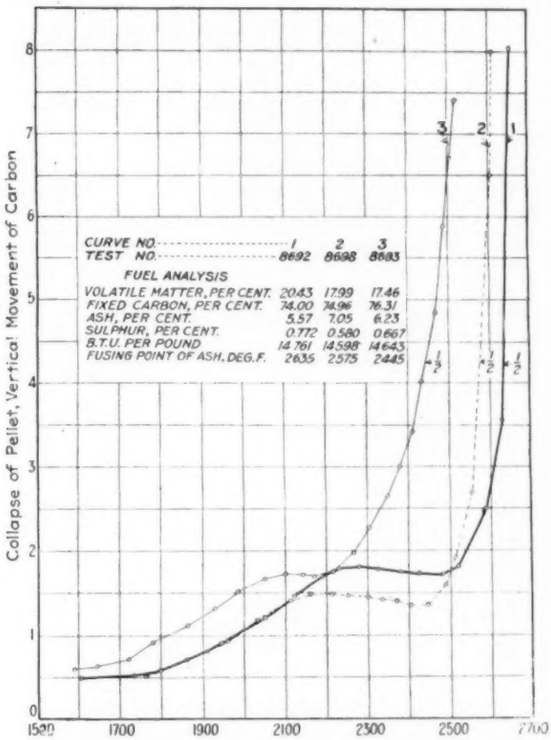

Collapse of Pellet, Vertical Movement of Carbon
Temperature in Furnace at Test Pellet, Degrees Fahrenheit
CURVE NO. 1 2 3
TEST NO. 8692 8698 8693
FUEL ANALYSIS
VOLATILE MATTER, PER CENT. 20.43 17.99 17.46
FIXED CARBON, PER CENT. 74.00 74.96 76.31
ASH, PER CENT. 5.57 7.05 6.23
SULPHUR, PER CENT. 0.772 0.580 0.667
B.T.U. PER POUND 14761 14598 14643
FUSING POINT OF ASH, DEG.F. 2635 2575 2445

FIG. 9. ANOTHER SET OF CURVES FROM ASH OF VARIABLE FUSING RANGE

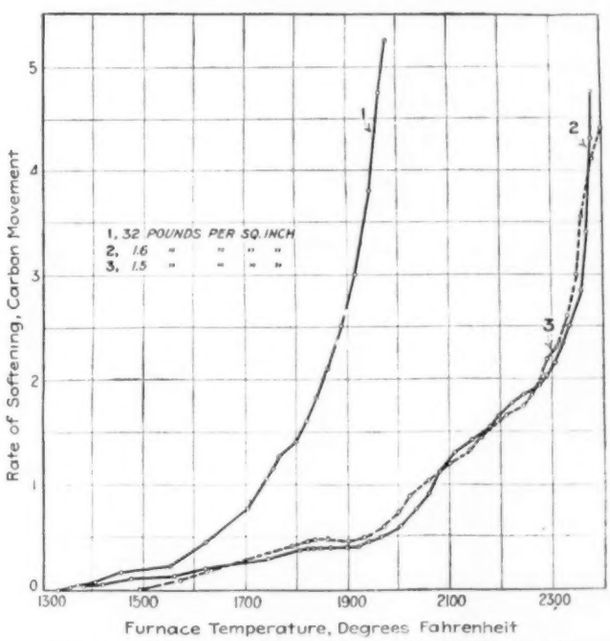


FIG. 10. LONG FUSING-RANGE ASH; GUMMY AND TOUGH CLINKER

ing required 25 min. and one 45 min." Curve No. 3: "Highly satisfactory, requiring only the dumping of the back grates to clean fires." Curve No. 4: "Proved highly satisfactory in every respect; it burned free and fast at a high temperature and did not clinker. With this coal, the number of fire cleanings in 24 hr. could be reduced to four and possibly to three."

Fig. 7, curves 3 and 4: "Proved so troublesome on account of clinker formation that the remaining cars of

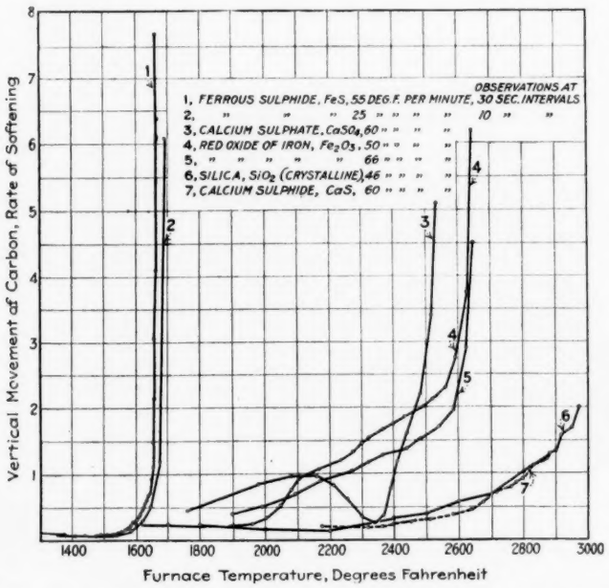

OBSERVATIONS AT
1, FERROUS SULPHIDE, FeS, 55 DEG. F. PER MINUTE, 30 SEC. INTERVALS
2, " " " 25 " " " " 10 " "
3, CALCIUM SULPHATE, CaSO4, 60 " " " "
4, RED OXIDE OF IRON, Fe2O3, 50 " " " "
5, " " " " " 66 " " "
6, SILICA, SiO2 (CRYSTALLINE) 46 " " " "
7, CALCIUM SULPHIDE, CaS, 60 " " " "
Vertical Movement of Carbon, Rate of Softening
Furnace Temperature, Degrees Fahrenheit
1400
1600
1800
2000
2200
2400
2600
2800
3000

FIG. 11. CURVES SHOWING SHORT-RANGE, VARIABLE-RANGE AND LONG-RANGE ASH

this shipment were rejected. Required 45 min. to clean fires after six hours' running." Curves 1 and 2: See curve 1, Fig. 4.

Fig. 8 (three cars from the same mine), curves 1 and 2: "Appeared to make a much harder clinker than either of the other cars." Curves 3 and 4: "Unsatisfactory because it clinkered to a troublesome extent."

Fig. 9 (three cars from the same mine), curves 1, 2 and 3: "Rather dull burning. Did not clinker to any great extent, and from its behavior, this was likely due to inability to keep the fire burning at a high furnace temperature."

F F F Boiler-Water Treatment

A rather novel method of boiler feed-water treatment known as F F F has been produced by the Paige & Jones Chemical Co., Inc., 51 E. Forty-Second St., New York City. The chemicals are put up in solid form about the size and shape of baseballs (Fig. 1), each ball weighing about a pound, and are placed in the supply line to the boilers. The balls dissolve quickly in hot water and slowly in cold and, being in the form of a highly compressed solid, there is no waste in handling or in evaporation.

The combination of chemicals of which the balls are composed is proportioned to render the scale-forming matter and the corrosive elements of the feed water harmless when fed into the boiler. As the balls are compounded to meet the requirements of the feed water needing treatment, the chemicals dissolve and disintegrate the scale-forming matter, and the function of the graphite, which is used in combination with the chemicals, is to mix with the sludge and keep it so soft that it can be blown out through the blowoff pipe or washed out with a hose when the boiler is open for inspection. The graphite also prevents the sediment from adhering to the sheet or tubes. Boiler water used at the plant of the Warner-Quinlan Asphalt Co., Warners, N. J., carries a heavy lime content. This plant operates one 250- and three 500-hp. water-tube boilers. Through the courtesy

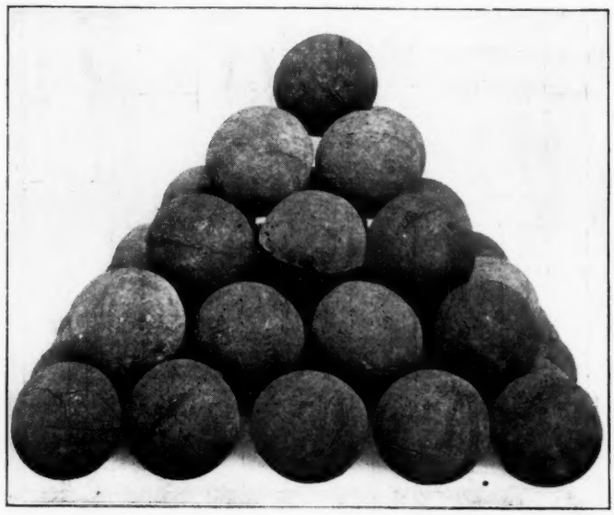


FIG. 1. F F F BOILER-WATER TREATMENT BALLS

of Superintendent Miller and Master Mechanic Charles Almquist, a photograph of two of the large boilers was taken, also one of the feeding devices used in dissolving the balls (Figs. 2 and 3). Considerable experimenting

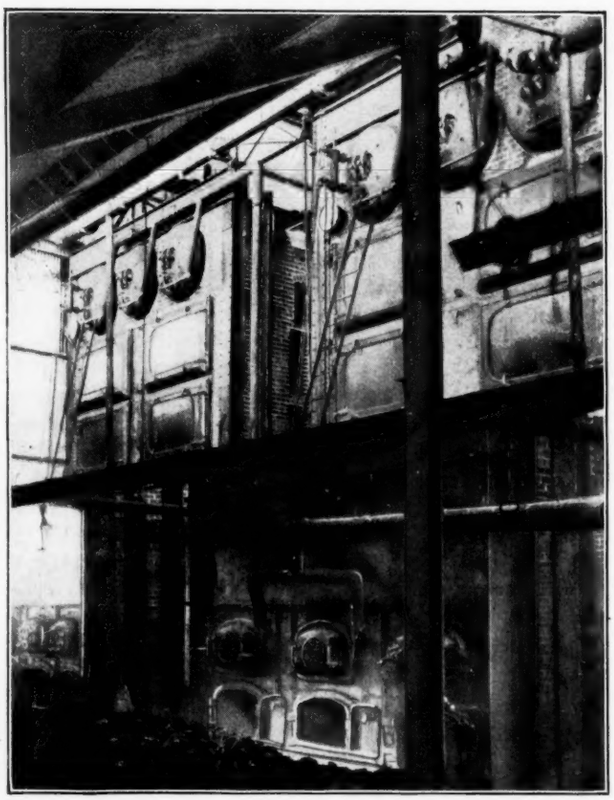


FIG. 2. TWO OF THE BOILERS USING THE F F F TREATMENT

has been done at this plant with feed-water treatment. The F F F treatment has been carried on with No. 3 boiler for a little over a year, and although the water is extremely bad as to lime, after 12 months the tubes show only a thin skin of scale.

Fig. 3 shows the arrangement for dissolving the balls and feeding the chemical into the boiler. A piece of

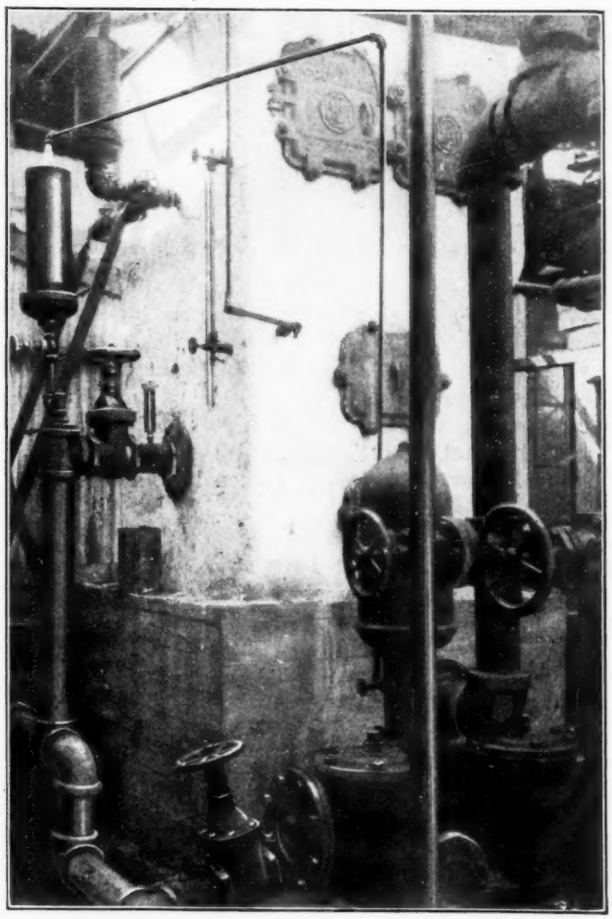


FIG. 3. HEATER AND RESERVOIR FOR DISSOLVING THE BALLS

5-in. pipe is fitted with a reducing cap on the bottom end and is open at the top. The bottom of the cylinder is piped, with a globe valve, to the pump suction from the heater. A small pipe from the discharge of the pump, also fitted with a valve, is piped to allow a stream of hot water to flow over the balls in the reservoir, which holds ten.

While the feed pump is running, a certain amount of the composition is dissolved and fed into the boiler with the feed water. When the pump is stopped, the water flowing over the balls ceases, or if the pump is slowed down, the stream of water is reduced in volume and less chemical is fed to the feed water. A one-pound ball is sufficient to treat about 8,000 gal. of raw water at this plant per 24 hr. With this method of feeding each gallon of water receives its proportion of treatment.

As there is nothing to weigh or to measure, the boiler attendant simply puts the balls into the feeder and pays no more attention to them until another set of balls is required.

Another way is to dissolve the required number of balls for a 24-hr. run in a pail of boiling water and sniff it through the feed pump or the injector. Still another way is to feed the balls from an open tank, hotwell or filter box, always feeding from the bottom, as otherwise the graphite will settle and accumulate and cannot get into the boiler.

Small Investors Beware!

The perpetual-motion promoter is again abroad. A month or more ago there appeared in the *Sunday Globe*, of Boston, an advertisement of an inventor who wished to enlist capital for and assistance in developing a perpetual-motion device. Letters from reputable capitalists and manufacturers have failed to bring out a response, from which it is to be inferred that the advertiser is angling for the man or woman with a few dollars to

Perpetual Motion

POWER & HEAT & LIGHT CO.
(Will be organized)

Invest With Us—Thousandfold Your Money.

We Harness Gravitation—We Monopolize the World.

I demonstrated to hundreds of people of all classes—included many Mechanical Engineers—within the last few days. My offer stands. I am authorized from my investors to pay One Thousand Dollars to anyone, should I fail to prove at my demonstration, that I have Invented Perpetual Motion and Power-machines of millions of horse-power capacity, or if anyone is able to disprove this fact; and further, I also will offer One Thousand Dollars to anyone, should I fail to prove at my demonstration, that I have discovered the secret to disattract (counter-attract) the attraction of the Earth directly. In other words, the Earth attracts the whole weight, when same drops. When same is lifted to its original position, I counter-attract the attraction of the Earth 62½% positively—that is, 50% directly and 12½% indirectly. In other words, there is no attraction of the Earth on 62½% of the weights, when same are lifted to their original start, but there are about 12½% of friction, so my actual gain, of the weight dropping, is about 50% net.

I challenge the Scientific World to disprove this fact. Is any Engineer ready to disprove this fact and get my offer of $1,000.00? You may deny a fact by closing your eyes and swear you cannot see it, but, nevertheless, the fact exists—and soon Gravitation (Perpetual Power) will furnish all the Power and Heat and Light for the whole world.

Will demonstrate free, at our temporary office, 621 Michigan Ave., City, every day until 10 P. M.

There are two chances open for you, if you will act at once and investigate. First, the chance is open for you to come in on the ground floor, in the revolutionizing power of the world, and, second, you get paid for your time, should I fail to prove this statement. Then you get my offer of $1,000.00. Of course, you are unable to disprove my facts, but you have a chance to invest in the future power of the world, the inexhaustible power of Gravitation. Good things do not last long, therefore if you wish to invest and thousandfold your money, you will have to investigate at once!

You cannot afford to neglect an investigation! How would you account for your gross neglect, to yourself and your family, in five years from today? This stands investigation—why not investigate? Why miss this diamond opportunity? Suppose if I would tell you I have discovered the largest diamond field in the world, and I offer a $1,000.00 to prove it, would you investigate? If I tell you I discovered the secret to harness the inexhaustible power of Gravitation, which will furnish all the Power, Heat and Light for the whole world, and I offer $1,000.00 should I fail to prove it—a proposition millions of times more profitable as all the diamond fields of the whole world combined!—are you going to miss to investigate? How are you to account for your gross neglect to yourself and your family?

We shall build five horse-power machines and exhibit everywhere. We shall build machines of millions of horse-power. We are able to make electricity cheaper than water-power. Do not fail to investigate! Invest with us! Invest with us! Please do not ask demonstration by mail.

RICHARD ULHAM, Inventor.

invest rather than for the enlistment of the interest of a concern which would make a real investigation of the merits of his device.

The advertisement reproduced herewith appeared in the Detroit *Free Press* of Sept. 30. At our request a mechanical engineer of that city attended one of the demonstrations. He writes:

> I visited the place indicated in the advertisement, located in an old store, with seats (folding chairs) enough for 40 or 50 people, found about 15 or 18 men seated, listening to a speaker with bushy black eyebrows, thin face, of unknown nationality and a very poor command of the English language, pointing to a number of crude charts hung on the wall, using a pointer which consisted of a handle for a window or wall brush, about 8 or 10 ft. long.
>
> I sat listening to his lingo for about ten minutes, during which time he spoke of falling weights of 150,000 lb. each. I interrupted his jangle by asking him if he had ever constructed one of his machines. He answered that he had not yet. I then asked how he purposed to raise the weights to their elevated position. His reply was by overcoming the law of gravitation. Asked how he purposed doing this, he was rather unable or unwilling to explain.
>
> The asking by other listeners of one or two technical questions, which he did not appear to comprehend and could not answer intelligently, was enough to cause him to close his discourse and ask his inquisitive listeners to leave or rather to tell them that they would have to come again.
>
> During the time I was there, no one put in any claim for the $1,000, nor did I observe anyone "getting in on the ground floor."

Reducing Vacuum Below 26 In. does not materially increase the efficiency of reciprocating engines, but in turbines there is ample space or passage for large volumes of steam and the lower condenser pressure can be fully utilized.

The Mechanical Design of Turbo-Generators

By William Knight*

SYNOPSIS—The mechanical design of turbo-generators is as important as their electrical design and in most cases, for very high speed machines, is a larger problem. Considering that a mass of 1 lb. rotating at 3,500 r.p.m. at 1 ft. radius develops a centrifugal force of 2 tons, it is easy to conceive the tremendous forces existing in a high-speed rotor, which must be taken care of when designing it. It is necessary to provide a construction strong enough to withstand the centrifugal forces and stiff enough to avoid vibrations. The machine must be well ventilated in order to avoid an objectionable rise in temperature of its parts and must run without giving rise to unbearable noise. The object of this article is to show some of the mechanical problems involved in the design of alternating-current and direct-current turbo-generators.

The shaft of a turbo-generator must be so designed as to give safe stresses and deflections of such a magnitude as to keep the running speed well below the critical speed. Several methods of figuring the critical speed of a rotating shaft are used. The one most commonly employed consists in finding the deflection curve of the shaft when supported at the center line of the bearings and statically loaded with the weights of the rotating parts attached to it, and figuring the critical speed by using the method suggested by Professor Morley (*Engineering*, Vol. 88, p. 135, 1909). This method, which makes use of the deflection curve of the shaft when statically loaded, is not strictly correct, but the results obtained are close enough for every practical purpose.

The running speed of the shaft should be, whenever it is practicable, about 60 per cent. of the calculated critical speed, and a running speed of 72 per cent. should be avoided, because some objectionable vibrations are likely to occur and it might be considered as a lower critical speed.

Vibrations in a rotating shaft must be avoided, but in the case of turbo-generators they are particularly serious on account of the high speed of rotation. To prevent vibrations the dynamic balance of the rotor must be obtained as carefully as possible and in order to facilitate balancing, the balancing weights should all be of the same mass and preferably be located all on the same radius.

Vibrations can also be produced by the bad design or the poor construction of journal boxes and pedestals or by an unbalanced coupling. The babbitt in the journal boxes must be well secured to the cast-iron shell and a sufficient number of anchoring buttons provided to prevent the bearing metal from becoming loose. A sufficient clearance should be provided in the journal boxes to secure a good film lubrication.

*Engineering Department, Crocker-Wheeler Co.

The bearing pressure must be kept reasonably low, and in the design of bearings a generous factor of safety should be used that will allow them to withstand without injury an eventual overload produced by some parts that may get out of balance, in which case bearings of poor design or bad construction will aggravate the damage that may be produced before the machine is stopped. Some practical formulas and useful charts on bearing design were published by A. K. Pedersen in the *American Machinist* of Dec. 18 and 25, 1913.

The cutting of keyways on shafts is also, in some cases, a cause of troubles due to some internal stresses being relieved during the process of cutting, with a consequent tendency for the shaft to warp. Annealing would probably help in preventing the trouble, but annealing reduces the ultimate strength and lowers the elastic limit of the material, and in a shaft that may happen to contain a lower percentage of carbon than specified this may be very objectionable.

The best practice would probably be to buy the shafts rough-turned, oil-toughened and annealed and to cut keyways as small as consistent with the torque to be transmitted. In calculating stresses in the shaft, allowance must be made for an eventual unbalanced magnetic pull produced by the eccentricity of the rotor due to wear in the bearings. The shaft should be strong enough to allow about $\frac{1}{32}$ in. wear in the journal box without being sprung in the weakest section (ordinarily at the shoulder of the journal) under the influence of the unbalanced pull produced by the reduction of the air gap. The shearing stress in the shaft at the coupling must be sufficiently low to allow for an eventual short-circuit, which may produce a momentary overload of 10 or 20 times the normal load torque, and in figuring stress in that portion of the shaft it is better to figure on a resisting section of radius equal to the distance of the center of the shaft to the bottom of the keyway, because the cutting of the keyway considerably weakens the shaft in torsion.

The distance between pedestals must be made as short as possible, and it is well to remember that the deflection of a shaft increases almost directly as the cube of the span.

Some Details of Rotor Design

The high peripheral speed of alternating-current and direct-current turbo-generators makes it imperative to give proper consideration to the high centrifugal forces of the rotor. All force fits must be proportioned in such a way as to prevent any part from becoming loose when the machine is rotating at the maximum speed for which it is designed (otherwise the rotor may be thrown out of balance), and the stresses produced by the centrifugal forces must be well within the elastic limit of the material.

The body of the rotor core of a turbo-generator is sometimes made up of a steel bobbin with the field coil wound around a central cylindrical core; at other times it

is cast or forged solid with the shaft with strip coils in slots at the periphery; it is also built up with steel punchings bolted together and carrying the rotor winding in proper slots at the periphery, secured with wedges the size and shape of the slots being determined by electrical considerations. A central hole permits of forcing it on the shaft.

In designing this last type of rotor core, the tooth stresses produced by the centrifugal forces of the rotor winding and wedges and, still more important, the stresses and expansion of the rotor at the bore must be given proper attention. Under the influence of the centrifugal forces the punchings will expand, and if they are not forced on the shaft with a sufficient force fit, a loose core will result when the machine is running.

In figuring stresses and expansion of the rotor punchings, they can be considered as straight disks carrying an outside load uniformly distributed at the periphery. After finding the increase in diameter of the bore at overspeed, due to the centrifugal force of the disk itself and that of the projecting mass attached at the periphery, an initial force fit of the punchings on the shaft must be given a little larger than the calculated expansion.

Metal Wedges Being Used

Wooden or fiber wedges in slots are most generally used, but owing to the ever-increasing peripheral speeds, metal wedges properly insulated from the core are taking their place. A serious objection to them is to be found in the difficulty of driving them into place and the increased rotor losses due to eddy currents.

An effective type of metal wedge that almost eliminates these criticisms is described by Prof. A. B. Field in a paper presented last year to the Institution of Electrical Engineers and abstracted in the *Electrician* of Nov. 26, 1915. The wedge is made up of three pieces. A central bronze part is inserted in the slot and pressed down under great pressure, and two steel liners, one on each side, are driven into place without any friction on the top surface of the insulated coil.

In order to prevent any shift of the coil in the slots when the machine is running, on account of the high centrifugal forces developed it is almost impossible to counterbalance these centrifugal forces with an initial compression of the coils produced by the wedge. However, a suitable succession of applications of very high pressures, with a baking process interposed, will reduce to a small amount the further yielding of the material when the machine is running, even if the compression of the wedge in the slots does not create a compressive force quite equal to the centrifugal force of the coils at overspeed.

Rotors are sometimes built up of openhearth rolled-steel plates, with no hole at the center and with a flange at each end, forged solid with the shaft. The plates and flanges are fastened together with chrome-nickel steel bolts stressed up to approximately 40,000 lb. per sq.in.

This construction, because of the omission of the central hole, will greatly reduce the stresses in the plates, and the reduction in the size of the forging to the end flanges with only a piece of shaft attached to them, will insure stiff construction and good work at lower price.

A description of a rotor of this type followed by an interesting discussion is to be found in the paper of A. B. Field already referred to.

The problem of supporting the rotor coils projecting at the ends of the rotor core is also an important one. This is accomplished by the means of two rings, one at each end, made of some high-grade material having a yield point sufficiently high to take care of its own centrifugal force and that of the projecting coils. This ring is self-supporting and does not need any radial connection with the shaft, but owing to the eventuality of a short-circuit taking place, it must be keyed to the rotor in order to take care of a considerable retardation shock. Magnetic and electric difficulties militate against the use of steel coil-retaining rings, but if a more suitable material with the same physical properties cannot be substituted, mechanical considerations must take precedence over everything else.

In some cases wire banding is used in place of the solid end-ring construction for supporting the coil at the end of the rotor, and many designers prefer this method of banding, because it does away with the bad feature of not being easily taken off after being shrunk on, if a movement of the winding is noticed.

The quality of the material in wire bands is more easily guaranteed than in the case of a solid ring, and a flaw can be noticed when it is put on. It can be obtained of a more ductile quality, and if there is some unbalance in the loading of it, the material will yield more easily and relieve excessive local stresses. Very often the banding wire is fastened at intervals with solder, and if this is not carefully done, the wire is weakened by annealing it.

In the case of rotors of the bobbin type, a sound and well-balanced forging must be obtained and the field coil around the central core must be put on under an initial tension of about 10,000 lb. per sq.in., such as to make sure that it will not become loose at overspeed. The stresses produced by the rotation in the field coil are directly proportional to the square of the radius of the pole over which it is mounted.

Commutator Design and Construction

One of the most troublesome parts of a direct-current turbo-generator is the commutator, and special care must be taken in its design, construction and erection if serious troubles are to be avoided. A commutator is subject when standing still to some initial stresses which must be imposed on its component parts in order to have a stable construction after the centrifugal forces and the expansion stresses set in when the machine is running. For high-speed commutators the shrunk-ring type is used and for slower speed another type of commutator with wedge-shaped clamping rings secured by bolts and supported on a spider.

In the first case it is essential to use the right size of high-grade steel rings, properly spaced, in order to have a tight commutator and to prevent excessive deflection of the commutator bars. A commutator bar between two connecting rings can be considered as a beam fixed at both ends and subject to a load varying from a maximum at the rings to a minimum at the center of the span. This variable force is represented by the outward push exerted on each bar due to the tangential compression between the bars and the mica sections produced by the shrinking on of the rings, and compression, which is a maximum under the rings and gradually decreases toward the center of the span. Besides this variable load,

the bar between two consecutive rings is subject to a uniformly distributed load produced by the centrifugal force and to the expansion stresses due to the variation in temperature of its parts.

A good analysis of the combined action of the stresses produced by these three causes, accompanied by proper designing formulas, was given by C. C. Hawkins in *The Electrician* of Mar. 26, 1915.

In the design of the slower-speed type of commutator using wedge-shaped clamping rings, particular care must be taken in providing a sufficient total section of clamping bolts to secure a tight commutator at the maximum speed at which the machine is going to be run. The grip on the bars, which must stand the wedging action of the commutator flanges, usually is the weakest part of the bar, and the most stressed section is ordinarily the one at right angle with the bearing surface on the grip. An angle of 37½ deg. on the grip will be found to be preferable to a smaller angle, in the securing of good results.

The clamping bolts also will be subject to severe stresses produced by the variation in the expansion of the commutator bars and bolts, due to the heating, which may be enough to stress the bolts beyond the elastic limit of the material, leaving a permanent set, which, when the commutator cools down, will relieve a part of the initial compression between the commutator bars and the mica sections. In order to prevent this undesirable effect of the expansion stress, it is necessary to provide some sort of spring washer or nut lock between the commutator flange and the nut of the clamping bolts that is stiff enough to withstand the pull of the bolt when initially stressed up to, say, 10,000 lb. per sq.in. without closing down flat. This will allow the commutator bars to expand axially without adding any more stress to the bolts than is required to produce a further compression of the lock washers equal to the axial elongation of the commutator bars.

Special Lock Washers Necessary

Ordinary lock washers are not suitable because they are not stiff enough. A ⅜x⅜x1-in. lock washer becomes flat under a load of 2,800 lb., which corresponds to only 5,100 lb. per sq.in. stress in the bolt.

A type of lock washer called the "Hipower," which looks much like the ordinary plain lock washer and is made for ¾-, ⅞- and 1-in. bolts, is stiff enough to serve the purpose. For instance, the 1-in. size to close down almost flat requires a compressive force of 10,000 lb., the total deformation being 0.10 in. and the corresponding stress in the bolt 18,000 lb. per sq.in. By using this type of special washer between the nuts and the commutator flange, when the clamping bolts are initially stressed up to 10,000 lb. per sq.in., the washers will not be within 0.02 in. of being flat. In addition, these washers are just as effective as the ordinary plain washers when used as nut locks.

A result of the centrifugal forces is the tendency to raise the insulating mica segments. This is due either to defective mica, or to a displacement of the shrunk-on rings, or to the fact that not enough initial tangential compression between the mica sections and the bars was provided for. To prevent this it is suggested that small longitudinal grooves be cut in the bars, the first one to determine the wearing depth of the commutator, which will provide, to a certain extent, a locking device for the mica segments.

To prevent heavy centrifugal forces with a consequent increase of friction at the brushes, a high-speed commutator cannot be made of too large a diameter, but this on the other end means an increase in face, increase in the length of shaft between bearings and a consequent danger of vibrations. A happy medium must be found in order to secure a good design.

The shaft under the commutator must not be made too small in order to minimize the difference in slope of the commutator at the ends, which, if too pronounced, will result in a grinding action on the mica rings.

High-Speed Commutators

The design of a high-speed commutator must provide for good ventilation in order to limit as much as possible the rise in temperature, and Messrs. Siemens have attained some very decided gains in this direction by allowing a draft of air through the commutator bars by means of axial ducts therein.

Besides being properly designed, a commutator must be accurately assembled and carefully handled during the erection of the machine. Slings or supporting blocks should never be placed under the commutator.

The brushes are another source of trouble. They should be properly staggered in order to minimize the wearing of grooves due to mechanical abrasion and to electrolytic disintegration of the copper under the positive brushes. On any given section around the periphery there should ride as many positive brushes as there are negative.

If graphite brushes are used, after a period of satisfactory operation sparking at the brushes is likely to appear. This is due to the fact that the graphite will polish the commutator surface, and because of the consequent reduction in friction, the brushes will tend to readjust their position in the brushholders. This will lift either the front or the rear tip of the brush, and sparking begins. An increase of pressure on the brushes will ordinarily cure the trouble.

Ordinary carbon brushes worked at 40 amp. per sq.in. will have about 40 watts of electrical losses per square inch, and the friction losses in a high-speed commutator are about 200 watts per sq.in., so that at least 240 watts per sq.in. of brush are turned into heat.

Ventilation of Turbo-Generator

In direct-current turbo-generators most of the losses occur in the armature; in alternating-current turbo-generators the bulk of the losses occur in the stator. Owing to the high losses and the relatively small masses of metal that can be utilized in dissipating the heat, some sort of forced ventilation must be devised.

In direct-current turbo-generators axial ventilation is most effective. By means of fans attached to the rotor at the end opposite to the commutator, the air can be drawn in at one end and made to pass through some axial ducts in the core and from there to go a part out through radial ducts in the armature and stator and another part to the commutator, from where a fan can drive it up to the stator end windings and from there out again.

For alternating-current turbo-generators a scheme of effective ventilation would be to draw the air in from both

ends of the machine by means of fans mounted on the shaft or attached to the rotor. Some sort of pressure chamber could be provided for in the end shields, from where the air, after circulating around the rotor coils and stator coils, would be forced through the air gap and thence out in the stator through radial ducts in the stator core.

Other ventilating schemes provide for a circumferential ventilation and consist in forcing the air through the stator frame in the stator core and out again to the frame, a small part only going to cool the rotor through the air gap. This scheme is particularly efficient with large alternating-current turbo-generators in which the rotor losses are possibly only 10 per cent. of the total losses.

Fans installed on the rotors of turbo-generators are not in general as effective as could be desired, and a much higher efficiency is certainly secured by providing a more efficient fan driven by a separate motor.

The air used for ventilation should be taken from outside the engine room, where it is cooler and free from oil, steam and dirt which would accumulate in the ducts and in other parts and produce serious troubles. This is especially true in the case of alternating-current turbo-generators on account of the high voltage. The dissipation of the heat is important and the Allgemeine Elektricitäts Gesellschaft has built large turbo-generators with water-cooled frames. A means of obtaining satisfactory results in cleaning and cooling the air before it is admitted to the machine would be to draw it through fine sprays of water and then through a series of vertical corrugated plates in order to free it from the water.

It has been suggested by some turbo designers to inclose the machine and cool it with a water jacket or freezing plant, but I do not know if this has been tried as yet.

Noisy operation of electrical machines is due to different causes, some of which must be traced back to the mechanical design of the machine, while others are due to electrical and magnetic reasons and cannot be entirely eliminated. This is especially true of machines built for the American market, which require open slots in order to be able to use form-wound coils, and are more noisy than European machines using nearly or quite closed slots. By using suitably designed magnetic wedges noise is reduced in machines with wide open slots.

A good analysis of noise in electrical machines is given by G. Pontecorvo in the *Electrotech. Zeitschr.*, pp. 547-550, May 15, 1913. The author divides the various of noises into magnetic load and ventilation noises.

Magnetic noises are generally of high pitch and penetrating, and it is difficult to prevent them and to foresee them when designing the machine. They are practically constant at no load and at full load. The vibrations that originate them act in a radial direction. With equal induction and equal number of poles, 60-cycle machines are more noisy than 25-cycle machines.

Load noises are of deep tone and sound like a roar, are louder with accelerating load and are often absent at no load. They are generally accompanied by vibrations of the machine and are produced by mechanical or electrical dissymmetry. They are more easily prevented than magnetic noises.

Ventilation noises are produced by the large masses of air set in motion and forced through the frame. They are of deep tone and not utterly unendurable and are very commonly found in machines using forced ventilation. They may be removed by reducing the size of the inlet of the air in the end shields or by decreasing the size and number of the ventilating ducts.

A deduction of Mr. Pontecorvo's investigation on the subject of noise was to the effect that the number of slots should be such as to avoid, when one slot is exactly departing from under one pole-tip, the arrival of another slot at the same position under the other pole-tip; this can be avoided by a convenient choice of the number of slots.

New Type of Choke Coil

SYNOPSIS—The functions of the choke coil are explained, along with a description of an improved type of 9- and 15-in. coils. In the new type sagging is prevented by bracing the turns.

When an alternating current flows through a coil of wire, it causes to be induced between the terminals of the coil a back pressure, which has an effect similar to introducing resistance in the circuit; namely, it reduces the flow of current. A coil of twenty to thirty turns wound in open air will offer very little opposition to the flow of current at 25 or 60 cycles, which are the normal frequencies of commercial alternating-current circuits. The back pressure in a coil increases as the current and frequency increase. A coil that would offer a small opposition at normal current and frequency will have a very high back pressure at high frequency. This fact is taken advantage of in the protection of electrical machinery against lightning discharges. A coil of wire known as a choke coil is connected in each leg of the circuit with a spark gap connected to ground through a suitable lightning arrester, as shown in Fig. 1. Each leg of the circuit is equipped as indicated in the figure. A lightning discharge is nothing more than an electric current of very high frequency and voltage flowing, for a very short duration, from the clouds to the earth. The frequency of such a discharge amounts to millions of cycles per sec. Therefore a coil that will offer very little choking effect to a 60-cycle current will offer a very high opposition

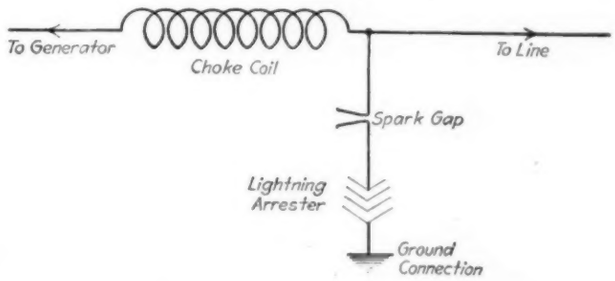


FIG. 1. CHOKE COIL AND LIGHTNING ARRESTER CONNECTIONS

to the current from a lightning stroke. Consequently, when an atmospheric current comes in over a transmission line, with a coil of wire connected in the circuit between the generator or other electrical apparatus and the line, as shown in the figure, it will be prevented from flowing into the machines and will jump the spark gap and be passed off to the ground through the arrester.

In the protection of electrical apparatus against lightning, a good choke coil is almost as important as a good arrester. The high frequency of lightning and other surges builds up an excessive voltage between the end turns of electrical apparatus connected to the line as well as a high voltage to ground. A choke coil connected ahead of the apparatus as shown will take the place of these end turns, and the strains will thus occur across turns whose insulation is especially designed to stand it. Even if the air insulation of some of these turns does break down, no harm will result, for the coils have no short-circuit energy to maintain an arc between turns.

A good choke coil must have sufficient inductance to choke back the greater part of each high-voltage surge, and high insulation to ground. It must also have high mechanical strength, so that it can support its own weight without sagging and can resist the stresses due to line short-circuits when they occur.

The Westinghouse Electric and Manufacturing Co. has recently added to its line of 15-in. choke coils a new line of smaller coils 9 in. diameter. Both sizes are constructed for outdoor or indoor mounting up to 130,000 volts, with a separate line of 9-in. coils for indoor mounting up to 49,000 volts. These coils are made up of a helix of aluminum rod in the 200- and 400-amp. capacities and of copper in capacities of 600 amp and above. The coil shown in Fig. 2 is used on circuits up to 49,000 volts; that in Fig. 3 up to 130,000 volts.

A typical feature of their design is the thorough bracing of each turn of the coils by wooden bracing clamps, illustrated in the figures, which gives them all the rigidity necessary to withstand the stresses due to line short-circuits. This bracing of the turns makes it unnecessary to reduce the diameter of the center of the coil and thus sacrifice much of the inductance in order to prevent sagging. Another notable feature is the construction of the insulator supports, which (except in the case of the 9-in. outdoor coils below 49,000 volts) permits inverting the insulators, so that the coils can be mounted either upright or suspended from the ceiling, thus simplifying their installation.

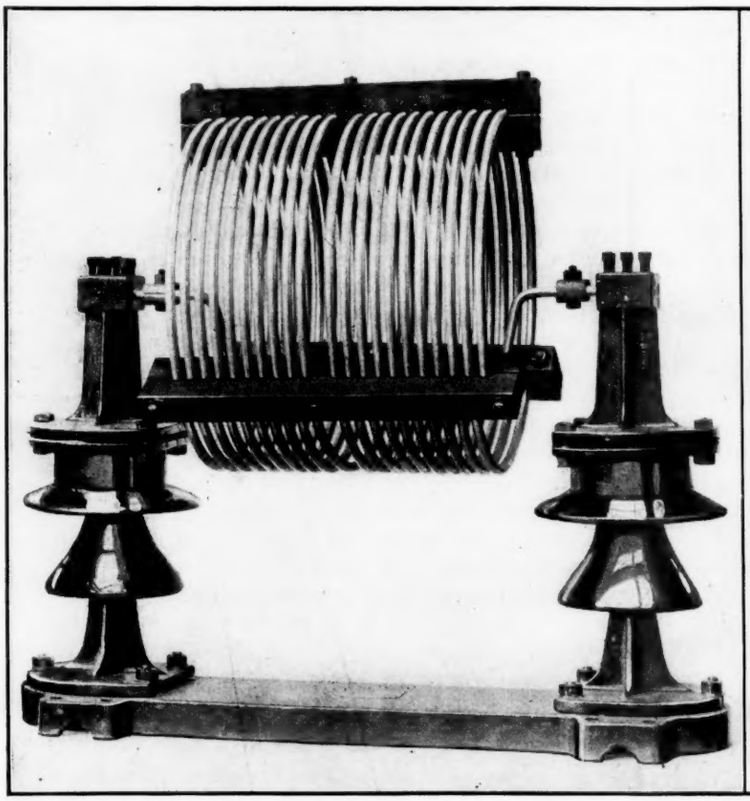


FIG. 2. TYPE OF CHOKE COIL USED UP TO 49,000 VOLTS

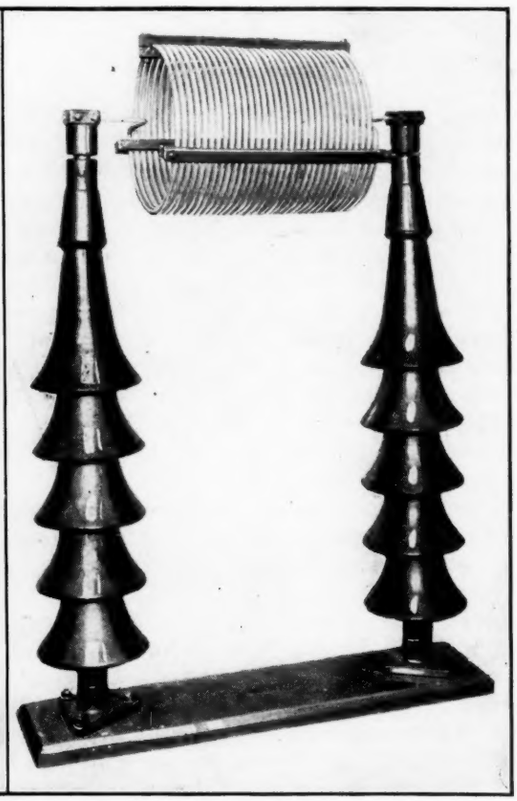


FIG. 3. TYPE OF CHOKE COIL USED UP TO 130,000 VOLTS

In the case of coils of very high voltage, where built-up insulator columns are used, the porcelain units are bolted together and it is therefore easy to replace broken porcelains or add more units when desired.

The 9-in. coils, now offered for the first time, have as much inductance as is ordinarily used and can be applied in a great many installations where lightning conditions are not abnormally severe and where the apparatus to be protected has good modern insulation. The 15-in. coils have about 5 to 7 times the inductance of the 9-in. coils and afford correspondingly greater protection. They are the largest helical coils now on the market for lightning protection and should be used wherever lightning conditions are very severe or where the apparatus is not new and rugged. For the protection of high-voltage motors and generators connected directly to transmission lines, even larger choke coils are vitally necessary to insure the proper protection.

Connecting Detached Buildings with Central Heat Supply

By Lewis Jones

SYNOPSIS—It is a comparatively easy matter to so connect a heating system with an outside supply that it will work satisfactorily. Suggestions are offered that will tend to make the undertaking less formidable and encourage this commendable enterprise.

The time is almost up for the "last call" for this season to connect up scattered buildings with the main heating plant. Hesitancy has held up a lot of work of the kind—hesitancy born of uncertainty as to whether the job will work satisfactorily or not, the dread of venturing on uncertain ground. But once a start is made, the problem becomes intensely interesting—like the fellow who got so enthusiastic in his tunneling work that he couldn't stop when he reached the other side of the hill. For the encouragement of those who may need it, it may be set down as an axiom that any steam-heating system that works right as a self-contained unit will work equally well when connected with a steam supply from a remote main plant or the street; and the chances are that it will work better, especially if the original system is of the type that returns the condensate directly to the boiler by gravity, without passing through a return trap or pump. The reason is obvious; that is, with the double-pipe gravity-return system the steam pressure acts equally on both supply and return lines and it is only the weight of the column of water (condensate) on the return side that keeps the steam pressure in the boiler from emptying it of water through the return lines, assuming that there is no check valve in the line. If there is, the height of the water column in the return system must be enough higher to overbalance the resistance offered by the check valve. In a system returning the condensate through a return-type trap or a pump, all the steam pressure is available to set up circulation and overcome the pipe friction and the return meets with little resistance. This is also the case with a remote service; the trap or pump discharges into the return line instead of the boiler. Therefore the return-line pressure may be equal to the initial steam pressure, and the system will still work as well as a direct gravity-return system, and whatever difference in pressure in the supply and return, is in its favor.

Supposing then that the building to be connected is at a considerable distance from the steam supply and on a lower level and has either a single- or double-pipe heating system, the problem is not at all difficult, provided only that steam is available of sufficient pressure to give some leeway. The supply line is led into the building and connected at any convenient point—front, back or side as the case may be—regardless of the location of the original boiler or the grade of the piping. Deferring the subject of drainage, if steam is then turned on one would expect the radiators to heat the same as before and the water level in the boiler to gradually rise, and it would become necessary to dispose of the excess water. The method and point of drainage is determined by the type of system, keeping in mind that the chief concern is holding the water back rather than getting rid of it. The conditions prevailing in the original system must be looked into and duplicated if it has worked satisfactorily; if not, it must be modified. If it is a wet-return basement-loop system, it won't do to attempt to operate it as a dry line because there will be a lot of water-hammer going on. This is especially true when the trap is connected so that the pipe system fills while the trap is filling and empties when the trap discharges—presto, boiler-shop music. The trap may, however, be connected at any point in a wet-return system regardless of the pipe grading, for it is obvious that if the return is to be kept full anyway, it makes no difference from what point the water is taken. The point of connecting to and from a building often very materially influences the cost, labor and cutting necessary. In some cases it becomes necessary to extend the return line to or near the point where it enters the boiler. Such cases will be found to be rare if the whole situation is taken in.

Too Large Return Lines Often Used

The size of the return line is usually overdone, as in fact is that of the steam-supply line, especially when reasonably high pressure is dealt with. The size of the feed line to supply a boiler of a given size affords a striking contrast to the size of the heating-system return lines usually provided by designers. It is not an unusual thing to see a building having a boiler of, say, 100 rated horsepower and fed through a 1½-in. pipe fitted with a 4-in. return pipe from the heating system. It is contended that since the pressure is low the pipes must be large, but it is the *difference* in pressure that causes the flow and this need be only enough to overcome the resistance at the required velocity of flow in any case. The difference in pressure between the boiler-feed pump and the boiler it is feeding, for example, may be only a few pounds.

When the flow is constant, as in a continuously discharging trap, the maximum velocity is much less than if a trap or pump is used that discharges a tank or receiver full in a short time, then shuts off until more water accumulates. In short, whenever possible, as it is in a great majority of cases, the water should be headed in the right direction and kept going steadily by the force or pressure in the system—which comes as near getting the work done without loss as is mechanically possible—and not intercepted and stopped by a pump or a trap operating intermittently. No great care need be taken to grade return pipes except to protect them against freezing in case of a shutdown during cold weather, and even then they can usually be drained or blown out so as to be free from harm.

Draining the condensate from the supply line to the return is a comparatively simple matter. Since the pressure is usually considerably less in the return line, there

need be only a small trap used in any case and often the bleeder can be connected directly to the return piping of the building without a trap at all. It is a mistake to suppose that a steam-line drain at, say, the low point where the pipe enters the building and rises to connect with the system must have a steam trap at a still lower level, in which case the trap is in an almost inaccessible pit and gets little attention. It can as well be located on the floor above, because the steam pressure will deliver the water to a height at least equal to its pressure in pounds multiplied by 2.3 ft. There is therefore little justification for the location of traps in such places as they are sometimes found.

The level at which the main trap on a heating system is to be located is determined by the pressure, the height of the lowest radiator and accessibility. For a dry-return system the best place for the trap is usually below the line, simply allowing the water to gravitate to it, but if this is not the accessible place, the piping may be led downward from the low point, then turned upward to where the trap is, in which case the action of the water is that of any liquid in a U-tube with a greater pressure on one side than the other; consequently the water is delivered to the trap just the same as if it was at the lowest point but at relatively less pressure. With the wet-return system the trap must be placed at the level at which the water is to be kept above the line, usually not a hardship, and furthermore it must have an equalizing connection from the supply header, or its equivalent, to avoid the action just described, that of a U-tube. Otherwise the steam pressure will continue to drive the water up from the return until it is empty or partly so, and cause severe water-hammer. If, however, it becomes desirable to locate the trap much above the return line or above the lowest radiators, advantage may be taken of this action by placing a spring-loaded valve in the equalizing pipe, set to cause the desired difference (reduction) in pressure in the two lines to allow the water level to be lowered in the down side to any desired amount within the pressure limits. When once set, the resistance of this valve needs no further attention even when the pressure changes, as it deals only with the pressure difference.

One of the greatest bugaboos is the fear of excessive pressure drop, which causes the designer to "play safe" and put in lines unreasonably large in which the first cost is excessive, radiating surface increases the loss and the cost of upkeep is out of all proportion to the fancied advantage of little pressure drop even where it is purposely "choked" with a reducing valve before being permitted to start on its way. The pipe line itself makes a first-rate reducing valve if it is small and long enough. Another fallacy is the use of too large reducing valves, because they are so nearly closed or seated when the average or less than the average steam is passing, that they soon cut out and leak badly. Two small ones, set for slightly different pressure, or one small one and a bypass will last and work much better. The foregoing is written in the hope of encouraging the commendable enterprise of connecting all the buildings of a group, within a reasonable distance, together and supplying the heat from one good plant instead of from a lot of inefficient ones.

Carburetion with Different Grades of Fuel

By E. N. Percy

SYNOPSIS—Results of tests with gasoline, kerosene and distillate under different methods of governing showed the throttling governor to give smoothest and most economical operation. Carburetion with kerosene was not satisfactory for variable conditions and heavier oils could not be carbureted successfully.

Certain engineers in California desired the following information: What petroleum fuels can be carbureted? Is there any appreciable difference in carburetors? What is the effect and what are the limitations of preheating? What are the effects and limitations of water added to the mixture? What are the mechanical and thermal efficiencies?

These various factors have been matters of opinion and theory rather than proved facts. Therefore, a horizontal, single-cylinder, 7¼x9-in. gasoline engine of the four-stroke-cycle type was selected for the test. It operated normally at 300 r.p.m. The fuels tested were gasoline, distillate, kerosene and gas oil. They were tested under the following conditions:

First, with an injection attachment and the engine governed by hit-and-miss.

Second, with an ordinary carburetor in conjunction with hit-and-miss governing.

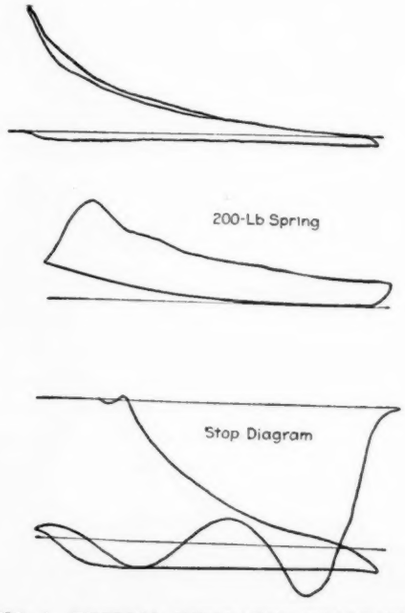


FIG. 1. TYPICAL INDICATOR DIAGRAMS

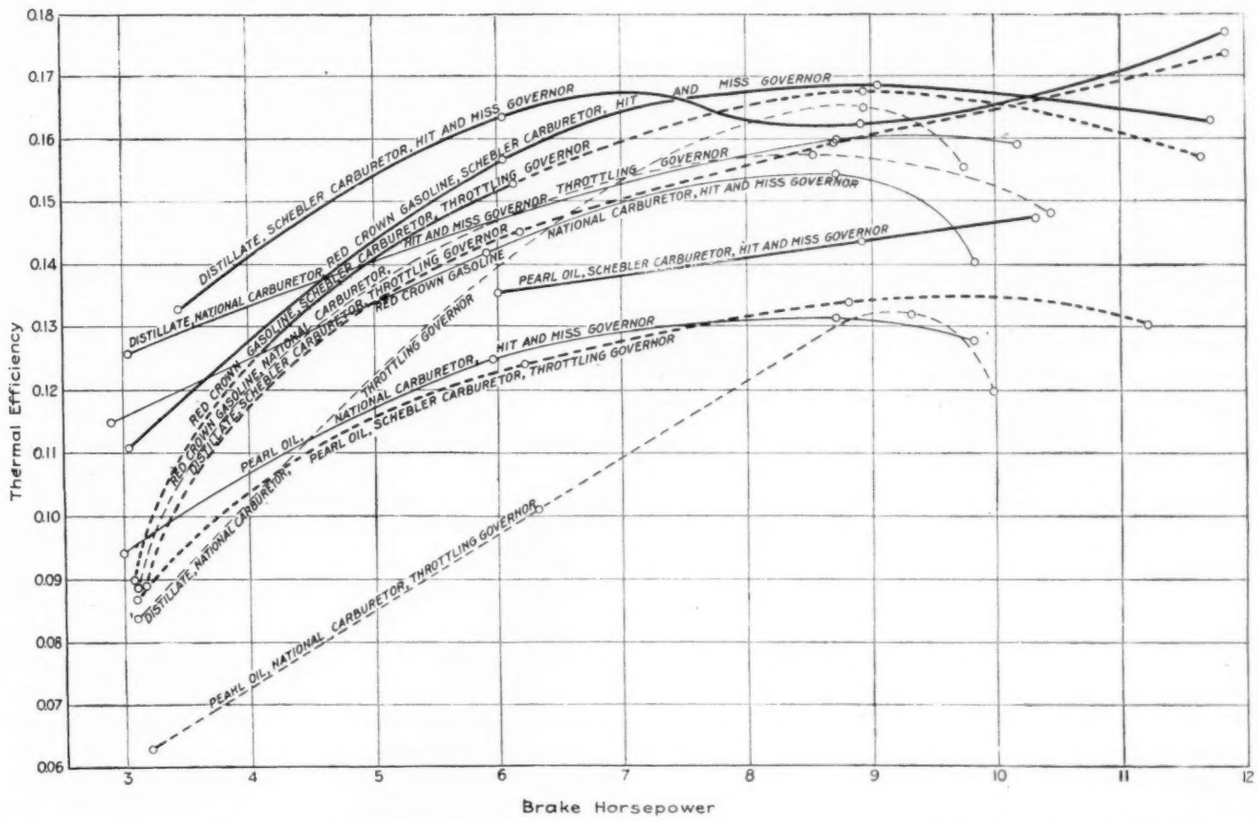

Thermal Efficiency
Brake Horsepower
DISTILLATE, SCHEBLER CARBURETOR, HIT AND MISS GOVERNOR
DISTILLATE, NATIONAL CARBURETOR, HIT AND MISS GOVERNOR
RED CROWN GASOLINE, SCHEBLER CARBURETOR, HIT AND MISS GOVERNOR
RED CROWN GASOLINE, NATIONAL CARBURETOR, THROTTLING GOVERNOR
DISTILLATE, SCHEBLER CARBURETOR, THROTTLING GOVERNOR
RED CROWN GASOLINE, NATIONAL CARBURETOR, HIT AND MISS GOVERNOR
PEARL OIL, SCHEBLER CARBURETOR, HIT AND MISS GOVERNOR
PEARL OIL, NATIONAL CARBURETOR, HIT AND MISS GOVERNOR
DISTILLATE, NATIONAL CARBURETOR, THROTTLING GOVERNOR
PEARL OIL, SCHEBLER CARBURETOR, THROTTLING GOVERNOR
PEARL OIL, NATIONAL CARBURETOR, THROTTLING GOVERNOR

FIG. 2. THERMAL EFFICIENCY (BASED ON BRAKE HORSEPOWER) WITH THROTTLING AND HIT-AND-MISS GOVERNORS

Third, with a so-called kerosene carburetor in conjunction with a hit-and-miss governor.

Fourth, with a kerosene carburetor in conjunction with a throttle governor.

Fifth, an ordinary carburetor and throttle governor.

The tests were each of four hours' duration ranging from no load to full load, and full paraphernalia was installed for taking all data necessary. The exhaust gases were also analyzed.

Fig. 1 shows a set of typical diagrams from the engine, the top one representing compression without ignition, the middle one full load, and the stop diagram at the bottom the suction and exhaust strokes at full load, shown to large scale.

The thermal efficiency varied from 6 per cent. to nearly 17 per cent., as shown on the various curves of Fig. 2, and the fuel consumption varied from about 0.6 lb. per b.hp.-hr. to over 1.4 lb., as shown in Fig. 3.

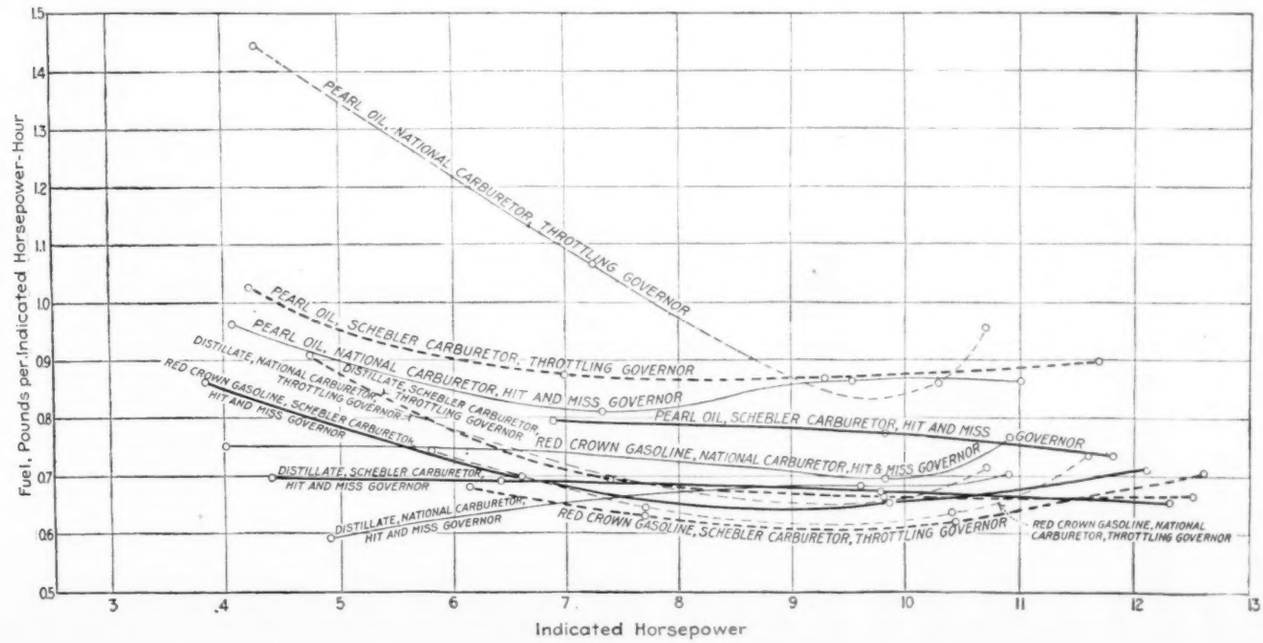

Fuel, Pounds per Indicated Horsepower-Hour
Indicated Horsepower
PEARL OIL, NATIONAL CARBURETOR, THROTTLING GOVERNOR
PEARL OIL, SCHEBLER CARBURETOR, THROTTLING GOVERNOR
PEARL OIL, NATIONAL CARBURETOR, HIT AND MISS GOVERNOR
DISTILLATE, NATIONAL CARBURETOR, THROTTLING GOVERNOR
RED CROWN GASOLINE, SCHEBLER CARBURETOR, HIT AND MISS GOVERNOR
DISTILLATE, SCHEBLER CARBURETOR, THROTTLING GOVERNOR
PEARL OIL, SCHEBLER CARBURETOR, HIT AND MISS GOVERNOR
RED CROWN GASOLINE, NATIONAL CARBURETOR, HIT & MISS GOVERNOR
DISTILLATE, SCHEBLER CARBURETOR, HIT AND MISS GOVERNOR
DISTILLATE, NATIONAL CARBURETOR, HIT AND MISS GOVERNOR
RED CROWN GASOLINE, SCHEBLER CARBURETOR, THROTTLING GOVERNOR
RED CROWN GASOLINE, NATIONAL CARBURETOR, THROTTLING GOVERNOR

FIG. 3. FUEL PER HORSEPOWER-HOUR WITH THROTTLING AND HIT-AND-MISS GOVERNORS

Many interesting facts that were at variance with common belief were gleaned from the tests. The mechanical igniters were tested for lag and by means of a chronograph demonstrated a lag from 21 to 25 deg. between the point of release and the point of ignition. The throttle governor gave the smoothest and most economical operation on all fuels, especially on light loads and thin mixtures. Distillate, kerosene and gas oil required heat and water in order to be carbureted and yet be compressed without preignition. The water corroded the exhaust valve and emulsified with the lubricating oil, interfering seriously with lubrication.

The results with gas oil were not satisfactory at all. Full power could not be developed, carbon was deposited, the exhaust filled with dense smoke and it was manifest that the fuel could not be properly carbureted.

Kerosene could not be properly carbureted at ordinary temperatures, and when sufficient heat was applied to properly accomplish this, there was a serious diminution of power due to the reduced density of the mixture, also preignition.

The carbon-dioxide content in the exhaust gases averaged about 11 per cent. and the carbon monoxide about 3 per cent., showing conclusively that combustion was imperfect throughout. Every effort was made to improve this combustion, but without success.

The surging of the gases is shown in the stop indicator diagram. The inlet valve was not mechanically controlled, and the gas surging appeared to synchronize with the chattering of the valve.

Combustion is without question a gradual process, and the maximum pressures are realized long after the point of ignition. Thin mixtures lengthen this interval. It is also lengthened by the admission of water or an increase in the gravity of the fuel. On heavy kerosene and gas oils the curve was still rising at the point of exhaust, indicating that they burn very slowly unless reheated, in which case there is apt to be preignition with the curve rising before the end of the stroke and then looping backward.

In conclusion, the tests indicated that gasoline and distillate can be used under most gas-engine conditions, especially if a little heat be added to the mixture. It would appear that special types of carburetors are necessary for the proper vaporization of kerosene and that heavier products of petroleum cannot be carbureted in the type of engine used. The kerosene carburetors operate with fair success for a given set of conditions, but are much more sensitive to changes of temperature or other conditions than with other fuels.

Vibration in Steam Turbines

A correction or amplification of one point in his article on "Vibration in Steam Turbines," that appeared on page 189 of our Oct. 3 issue was received from Mr. Fisher too late to incorporate in the original article and is given as follows: The bearing clearance should be from 0.008 to 0.012 in. for journal diameters up to and including 6 in., 0.015 for 7- and 8-in. journals, 0.020 for 9- and 10-in. journals and 0.025 for journals over 10 in. diameter.

The greater clearances for the larger journals are necessary to allow for expansion when heated. The journal is understood to mean that part of the shaft inside the bearing.

Elevator Machinery Lubrication

By Jacob Gintz, Jr.

In the care of elevator machinery the proper lubrication of the various parts, including the cables, rails and guides, should be given special attention.

The motor bearings should be oiled at least once a week; that is, the oil wells should be filled. Care must be taken that no oil leaks or runs inside of the motor, as it will soak into the field coils, causing a short-circuit or a ground. The oil in the gear case should be given attention from time to time and kept at least three inches above the worm. If the gears become rough, put about one-half pound of powdered sulphur into the gear case with the oil and in a day or so the gears will be in normal condition. The gear case should then be cleaned out and fresh lubricant put in, consisting of two parts castor oil and one part cylinder oil.

The greasing of the rails is also important. They should not be allowed to become gummed, as this will make the car drag when on the up motion, causing the motor to consume more current than necessary and produce an excessive strain on the cables. On the down motion, the car may drag to the extent that the cables will become slack, which may cause the slack cable switch to open and stop the motor. Should the car suddenly start down after the motor is stopped, with the cables slack, the sudden tightening and jar would be liable to pull out the thimbles which hold the cables fast to the car, or the cables may break and cause a serious accident. It is necessary that the rails be washed down with kerosene occasionally and oiled with good cylinder oil or a mixture of seven parts of cylinder oil and one part of graphite. If the rails or shoes on the car become rough in spots, apply powdered sulphur; this will remedy the defect.

The traveling or, as they are called, vibrating sheaves, which are the first sheaves the cables pass under as they leave the drum, must be kept well greased, so as to allow them to move freely back and forth on the shaft on which they revolve. Most of these sheaves are equipped with pressure grease cups, which are filled with a nonfluid grease. If the sheaves are not equipped with these devices, the shaft should be kept well supplied with a medium grease. If sufficient grease is applied, the sheaves when traveling one way will collect the grease and when returning will deposit some of it on the shaft. In this way the shaft and sheaves will be kept well lubricated. The duty of these sheaves is to keep the cables wound evenly on the drum and prevent them from riding over one another.

The overhead sheaves are keyed to their shaft; which turns in bearings that are equipped with grease boxes and are lubricated with a nonfluid but not too hard grease.

The oiling or greasing of the cables, especially new ones, is very important, to prevent them from rusting. A mixture consisting of equal parts of linseed oil and lampblack may be applied once a week on new cables until thoroughly soaked and about once every second month thereafter. The elevator manufacturers also furnish an oil for this purpose.

By following these few rules the wear and tear on all movable parts will be reduced to a minimum and much trouble avoided.

Editorials

Time Factor in the Power Plant

Many seeming inconsistencies will straighten themselves out and the way will be made clear for improvement in operation if its true value be given to the effect of time and of lag upon the various processes involved in power-plant operation. We have in mind not so much the more subtle influence of lag as upon the action of a governor, but its interference with larger operations, especially when those operations are intermittent. It takes time to heat feed water. There may be ample exhaust to heat the feed and heating surface enough to heat it to the desired temperature at the average rate, but if the water line is down and the load is heavy, the feed water may be going through the heater at two or more times the average rate and not have time enough to be heated as much as it should be.

A furnace may be proportioned and the damper set so as to furnish the right supply of air for the average condition, but if a charge of coal rich in volatiles is thrown on, it is practically impossible to get in enough air in the limited time available to burn the gases suddenly generated without cooling them below the point of ignition, and if they could be burned, the rate of combustion would be so great that the gases would not have time to impart their heat to the boiler. This refers to a heavy charge of fat coal fed all at once and not to gradual feeding over a portion of the furnace.

Reams of paper and acres of diagrams have been used to demonstrate that a Corliss engine cannot cut off at more than half stroke; and on paper it cannot, with the usual form of governor. It is the forward movement of the eccentric which brings the latch upon the valve gear against the trip upon the governing mechanism, and if this contact does not occur before the eccentric passes the line of centers and starts on its return, cutoff cannot occur on that stroke. But the eccentric must be set at least ninety degrees ahead of the crank in order to operate the exhaust valve properly, and even when a separate eccentric is used for the exhaust, the eccentric must be fairly up toward a right angle in order to give the necessary quickness of opening to the steam valve. Allowing then that, on paper, a Corliss engine cannot cut off beyond half stroke, it is a fact that it can and does make diagrams showing cutoffs as late as three-quarters stroke. The time element again. An engine running at ninety revolutions per minute makes the entire stroke in one-third of a second and makes the distance between half and three-quarters stroke in one-eighteenth of a second. If the valve were released at half stroke, the dashpot would have to close it in one-eighteenth of a second to keep the cutoff as early as three-quarters stroke, and when an engine shows a half cutoff on a diagram, it is probable that the latch is released considerably earlier in the stroke.

It is said that steam cannot remain superheated in the presence of moisture, for the excess heat will evaporate the moisture and be absorbed in the process. And so it will—give it time. In the same sense ice cannot exist above thirty-two degrees. But the ice lies on the curbstone in a sweltering sun and a rivulet of water trickles along the bottom of a pipe carrying a hundred degrees of superheat, and one will melt and the other evaporate—in time.

Doubtless many other instances will occur to the reader where moot and mysterious points might be settled by a proper consideration of the time involved.

Hydro-Electric Development in South America

Whenever our foreign trade is discussed, South America always comes to the front. The development of our Latin-American neighbor's enormous water-power resources is one of the most important features in the securing and building up of this trade.

One of the potent factors in almost every industrial development is cheap power and good transportation facilities, and the latter depends to a certain extent upon the former. In countries where coal, oil and gas are cheap, the power problem has been successfully met to a large extent by the use of these fuels. But where these resources are scarce, the power problem must be solved, if solved at all, by hydro-electric development. Therefore, industrial progress in Latin America depends largely upon the successful development of hydro-electric enterprises, and this would appear to be one of the channels through which our neighbor's trade can be secured. It seems reasonable that those who make industrial progress possible will be the ones who will be called upon to furnish the material to carry on the work.

Elsewhere in this issue is a survey of the hydro-electric possibilities in South America, in which the author analyzes the situation and points out some of the steps that must be taken to secure this trade.

Before the war South America relied largely upon European capital for industrial development and when this supply was cut off by the great conflict, the work on her public utilities practically came to a standstill. Now would seem to be the time for this country to come to our neighbor's aid and furnish the finance that will again give impetus to her industrial and economic development. As the author points out, hydro-electric investments, with the vast field open for general industrial enterprise, seem to be money well spent, as such investments not only give employment to American industries to supply building material, power machinery, etc., incident to the building of such plants, but also open the way for further expansion in the districts where industrial possibilities are opened by the power stations.

The European banks before the war recognized the wisdom of investing heavily in these enterprises, with the result that in most cases a preference has been given to the European goods. The development of the enterprises must not be left to the financiers alone. The

manufacturer must do his share in the building up of his trade, which means that he must do some developing of his own. He must study the markets among the possible users and educate them to a preference for American-made material, just as a market is developed in our own country.

The statistics for the German exports of hydro-electric machines to South America for the five years from 1909 to 1913 show that the sales increased 717 per cent. which indicates a good healthy demand for this class of equipment. Now that Europe for the present is temporarily out of this market, who is going to supply the demand? It is to be hoped that the American manufacturer will. But let him not be deceived that this will be an easy task, for there is every indication that some of the nations now at war are putting forth obstacles to this expansion of American trade under guise of military necessity, and after peace has been concluded they may be expected to redouble their efforts to regain the markets.

Humane Furnace Stoking

There are few men who can observe a dray horse straining to draw an overloaded truck and not feel resentment against the driver. The truck goes on its way, and the incident is forgotten until another similar occurrence. However, it sometimes appears that more humane treatment is accorded to the horse than to some men. The former has a monetary value, and if he is overworked or is injured or dies, it necessitates the expenditure of money to purchase another. The man can be replaced without expense.

When a power plant is laid out for a building, the boilers and engines are frequently put in almost anywhere that they will fit, and apparently no thought is given to the probable working conditions of the men who will be employed to operate them. Frequently, the furnaces are equipped with mechanical stokers, and the firemen are made to throw the coal from the floor into the hoppers—a man-killing job to say the least.

Other boiler rooms are so placed that the temperature is stifling, and the only breath of fresh air the firemen get is before coming on and after going off duty. This condition is often hard to avoid in city buildings where every foot of ground represents a small fortune, but in noncongested districts there is no good reason, except the desire to keep down the first cost, for not placing the steam plant where the workmen will be provided with natural light and plenty of air.

In some plants the method of handling the coal to the stokers is almost crude and compels the hardest kind of manual labor, that of shoveling the coal into a bucket, elevating it to a track and pushing the loaded bucket to a position over the stoker hopper where the fuel is to be discharged. By the expenditure of a few dollars the bucket could be equipped with a small motor, thus eliminating the dray-horse labor of the firemen. A tired, discouraged fireman cannot produce the best results, try as he will.

In a large power plant visited recently, the furnaces of the boilers were hand-fired, burning buckwheat fuel. The grates were about twelve feet long, requiring a good husky man to properly cover them, especially for a period of eight hours. Near the end of the eight to four o'clock shift another turbine was started, and although the additional load was light, the steam pressure began to drop until it was about twenty pounds below normal. The men did their best in a losing fight, but eight hours of grilling labor was more than human strength could endure. When fresh men came on duty, the steam speedily regained the normal pressure. Every ounce of coal burned under these large boilers had to be shoveled into the furnace from piles on the boiler-room floor, the supply coming from an overhead bin.

On another page of this issue is a short description of the method employed in firing boiler furnaces with a similar kind of fuel, but of a finer grade. Here the coal supply comes from an overhead bunker, but instead of being delivered in a pile on the floor, it is discharged into hoppers. Instead of the firemen being obliged to shovel the coal into the furnace, they spread it with a light hoe, requiring about one-tenth the normal labor necessary with the shovel. At the end of a shift the men are not exhausted, and more than that, fewer men are required in the boiler-room force.

As to the cost of the hopper system over that of straight hand-firing, there would be but little additional expense, and when considering the lightened labor of the firemen, the decreased labor cost and the better operating efficiency of the men, whatever additional first cost there might be would soon be canceled.

It would be well for consulting engineers, power-plant owners and others interested in the building of power plants to give more consideration to the comfort and welfare of the operating force. There would be but few if any cases where such attention to the human element of the steam plant would not result in a paying investment. There is always more than the first cost to consider.

The *Traction Bulletin* is authority for the following communication:

WHAT MAKES IT STOP?

Sparksville, June 9, 1916.

——— Gents: The gas engine you sent me stops when theres nothing the matter with it thats the trouble. it wouldent bee so bad if it stopped for some reason and anybody knows theres reasons enough for it to stop.

I received the book which you sent me which is named What Makes the Gasoline Engine Go. I ain't read it yet because whats the use reading it when I dont care what makes the gasoline engine go as long as it goes which mine dont only accasionly. what I want to know is What Makes the Gasoline Engine Stop. If you got a book called that send me one. I want to know what makes my gasoline engine stop when everything is o k and nothing is the matter except that it must be a rotten engine HIRAM DIGGS.

Hiram Diggs shows more common sense than is at first apparent. Some manufacturers are satisfied to publish literature that gives the impression that their products are foolproof and that under no circumstances will trouble be experienced. Troubles are likely to occur with most any piece of apparatus, and it would be better if manufacturers would act on Hiram's suggestion and publish something that will help the engineer out of difficulties when they occur.

The fireman who keeps the edge of his scoop trimmed is usually a trim fireman.

There is no paradox about warming up to a refrigera tion subject.

Correspondence

Commutator Trouble

I was recently called to investigate a peculiar case of trouble that developed in the exciter for a 500-kv.-a. alternating-current generator in a municipal plant. The trouble was experienced in the morning when the machine was started. It required from five to ten minutes for the exciter to build up, after which it would suddenly come up to voltage and carry the load without further difficulty.

Various theories were advanced, among which was a possibility of the field poles being constructed from a poor grade of iron, therefore requiring some time for complete saturation. A thorough inspection of the machine after shut down revealed nothing. The next morning before starting up, the exciter was given another rigid inspection which revealed that the commutator and brushes were covered with a film of transparent substance resembling paraffin, and on a closer examination it was found to be commutator compound. After several inquiries it was ascertained that the attendant was ordered to give the commutator several applications of the compound daily. After cleaning the commutator and putting in a new set of brushes, the machine built up almost immediately.

The trouble undoubtedly could have been located earlier had it not been for the fact that the engineer made his examination of the machine only after shut down, and the heat from the machine kept the compound in a semi-fluid state. This film of compound acted as an insulator when the machine was cold, therefore good electrical contact between commutator and brushes could not be maintained until the generator had run long enough to generate sufficient heat to melt the excess of compound.

Brooklyn, N. Y. SAMUEL SPAGNOLA.

Two- vs. Four-Stroke Cycle

In the issue of Aug. 29, page 315, Mr. Schreck does not bring out the point I would like to make, but paves the way and all but makes the point. He says that the four-stroke-cycle has given better results, for one thing, because of no bearing troubles. To obviate this difficulty he suggests the double-acting two-stroke cycle. Is he not suggesting still greater difficulties? The problem as he sees it is that of lubrication, but this does not seem so important. He states that the two-stroke-cycle engine has 30 per cent. less bearing surface per pound of pressure. Is it not equally true that it has 43 per cent. more pressure per sq.in. of bearing surface than the four-stroke-cycle if it has 30 per cent. less surface for the same pressure? Putting it this way is of course the same proposition stated conversely.

What is the answer and what shall we try, to overcome the difficulty? There are two logical methods. One would be to increase the bearing surfaces and the other to decrease the pressures. The bearing surfaces, it is safe to say, are as liberal as is practical. This leaves only the consideration of the pressures in the cylinder. I have made the statement many times in *Power* that the pressure of compression can wisely be reduced. This has been proved on my experimental engine in which nonvolatile fuel has been fired at compression pressures of 70 to 130 lb. This seems to present a wide field for improvement. The experimental engine in question was a four-stroke-cycle engine, but a two-stroke-cycle could be run under the same conditions. Dr. Clerk, the celebrated English engineer and the dean of all living internal-combustion engine authorities, has made some interesting experiments in regard to the temperature of the charge in a gas engine at the beginning of the compression stroke, after the engine has been under operation long enough to become well warmed. The results of his investigations show why it might be reasonably expected that the foregoing results could be obtained.

It may be asked what bearing this has on the two-stroke- vs. the four-stroke-cycle controversy. The point is that the compression pressure for best results is at present unknown. Engines should and can be built so that the compression pressure can be varied. The lower pressure will give far better efficiency at light loads, and by a careful tabulation of the results from engines run at different pressures and loads, the best compression pressure can be determined. Much stress is or has been laid on the fact that the compression pressure is the maximum pressure in the cycle. This is true in the Diesel, but for no thermodynamic reason. The pressure of compression can be exceeded by the combustion pressure by advancing the timing of the fuel injection. In this way the full power of the present engines can be obtained with a materially reduced bearing pressure.[1]

From the statements of Mr. Schreck it would seem that until the matter of the best pressure of compression or the proper clearance, as well as the proper use of fuel timing, is determined, the development of the two-stroke-cycle engine is work in the dark. Personally I do not favor the two-stroke-cycle engine, although some advantages can be obtained from this type. It would seem advisable, however, to develop the engine in its more simple form and then, when the lesson is learned, to go into the refinements. The matter of clearance is of prime importance and should be settled first. The oil engine is being developed rapidly for naval work, and the matter of economy at low loads is of vital importance. To vary the compression in a two-stroke-cycle engine is far more difficult than in a four-stroke-cycle type, but the most practical means for bringing this about would seem to be to design the engine for the minimum, then increase the compression by increasing the pressure of the scavenging air.

[1] See paper on "The Thermodynamics of the Marine Oil Engine," read before the Society of Naval Architects and Marine Engineers in the fall of 1914, an abstract of which may be found on page 145 of "Power" of Jan. 29, 1915. The effect on the bearing pressure at low loads was taken up in an article entitled "Some Observations on the Oil Engine," published in "Power," Mar. 11, 1913.

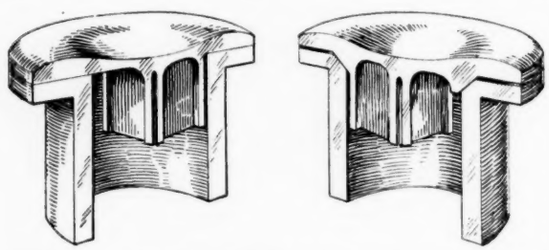
The contention of the writer for a long time has been that the oil engine varies from the gas engine only in the use of nonvolatile fuel and in the ignition by means of the high-compression temperature. It is suggested that a conventional double-acting gas engine of the two-stroke-cycle type be used for experimental investigations. The mixing valve and ignition means can be removed and a fuel pump and fuel valve installed. With careful adjustment this engine can be run on oil fuel without the substitution being noticeable by the output or by inspection of the indicator diagram. Perhaps the pressure of compression can be slightly increased with good results. The pressure of the gas engine is limited, but the best pressure for the oil engine is not and is yet to be determined. It is evident that there is a possibility of using the data derived from the operation of gas engines in the construction of oil engines, once the matter of clearance is understood.

Quincy, Mass. JOHN F. WENTWORTH.

Beveled Seats for Pump Valves

I should like to have some information in regard to pump valves. Which is better—a valve that has a bevel, or one with a flat seat?

I have had considerable trouble with our feed-pump valves, which are made of bronze and are flat. Why



PRESENT AND SUGGESTED FORM OF VALVE SEAT

would not a valve made as shown work better, as the flow of water would be easier? I should like to know if it would be worth a trial to have a set of valves made with beveled seats. GEORGE CLEVENSTINE.

Pottstown, Penn.

British Firms' Experience with Two-Stroke-Cycle Diesels

Apropos to the discussions that have appeared in *Power* lately concerning the two- vs. four-stroke-cycle Diesel engines, it may be of interest to add that during 1910 and 1911 the following British shipbuilders and engineers acquired licenses to build two-stroke-cycle Diesel engines from the Nürnberg works of the Maschinenfabrik Augsburg Nürnberg, of Germany: Harland & Wolff, Fairfield Shipbuilding and Engineering Co., Sir W. G. Armstrong, Whitworth & Co., Cammell, Laird & Co., Ltd., J. Samuel White & Co., Yarrow & Co. and Babcock & Wilcox.

What was the outcome? By reason of their agreements none of these firms was enabled to build any other make of two- or four-stroke-cycle Diesel engines.

Yarrows built a couple of experimental two-stroke-cycle engines of Nürnberg design, and the results caused them to place orders with Burmeister & Wain, of Glasgow, for several 1,000-hp. engines of the four-stroke-cycle type to drive the cruising shafts of some torpedo-boat destroyers then building for Japan.

J. Samuel White & Co. built several Nürnberg engines, but abandoned the design in favor of the Brons semi-Diesel type, which the terms of their licenses did not prevent them from building.

Harland & Wolff consequently afterward closely associated themselves with the Burmeister & Wain Co., of Glasgow, who had built the four-stroke-cycle engines for ships built at their yard, while the production of two-stroke-cycle engines with the other firms mentioned never passed the experimental stage.

J. I. Thornycroft & Co. purchased a two-stroke-cycle Diesel license from the Diesel Engine Co., who were associated with Carels, of Ghent. They received an order from the British Admiralty for a 1,000-hp. engine for the destroyer "Hardy." When last I was at Thornycroft works, I saw the first and only cylinder built for this engine, lying about in the yard apparently on the scrap heap.

Thornycrofts also built a 200-hp. two-stroke-cycle Diesel for the schooner "Netherton" and two 200-hp. engines for the yacht "Atair." In each case the engines were thrown back on their hands. L. O. THOMAS.

New York City.

What Bags the Boilers?

Most writers are of the opinion that feeding through the blowoff pipe at the rear of the boilers is the cause of the boilers being bagged, as described by Mr. Wright in the issue of Aug. 1, page 173. While there is no doubt that such a method of feeding is bad practice, the fact that the boilers ran for years without anything going wrong is evidence that there must be some other cause. Possibly the boilers are worked harder than they used to be, but he does not say so.

I believe that some types of stokers will produce bagging if they are not watched carefully, especially if the boiler is set too low, by producing the "blowpipe effect." This is most likely to occur if at times the demand for steam falls off, allowing the fires to become reduced and sediment to settle closely on some part inside of the shell. Then when the demand for steam increases and the draft is increased, the "blowpipe" gets in its work. When I was operating such stokers, I was careful to avoid blowholes.

To be able to judge intelligently, one should know more about the conditions existing, such as type of stoker if any, height of boiler from grates or fire, whether forced draft is used and if the boilers are working harder than previously. Perhaps Mr. Wright will favor us with this information. Anyway, if he succeeds in overcoming the trouble, he certainly ought to let us know how it was done.

In regard to the remedies suggested, the top feed is all right and by carrying the pipe down below the tubes settling of the carbonates on the tubes at the point of discharge is avoided. Feeding through the smoke-box into the front end does not look good. If the water should be cold, sweating will take place, causing the pipe to corrode.

I don't quite like Mr. Anderson's method described in the issue of Sept. 19, page 428; that is, admitting cold

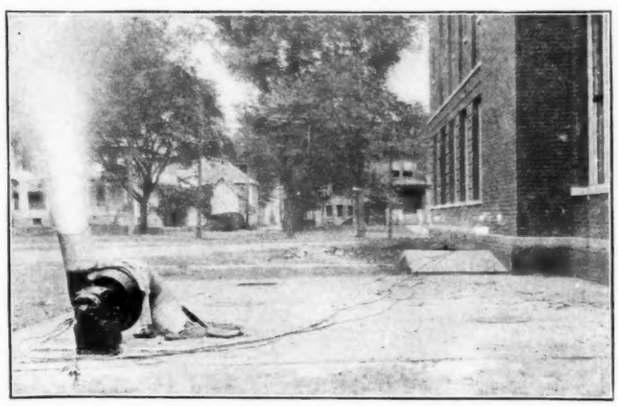
air into the furnace at the point of trouble. It looks like a waste of coal. If that part of the grate is hard to place coal on, why might it not be well to cover it with firebrick?

I would like to make a suggestion in regard to closing such discussions. Have you ever noticed that of those who ask for help, few ever acknowledge it or tell how they remedied the trouble if they ever succeeded in doing so? In the present case I would like very much to know what was the cause of the bagging and the remedy. We all know that "blowoff" feeding is not good practice, but boilers bag with other methods of feeding, and in this case there must certainly have been some other cause. It should be worth while to call the attention of correspondents to the fact that if we suggest remedies, we would naturally like to know the result.

St. Catharines, Ont., Canada. R. McLAREN.

Putting Out a Coal-Bunker Fire

Early last spring the soft coal in the bunkers of the Manual Arts Building of the public schools here took fire by spontaneous combustion. A direct-connected electric-driven fan was placed and connected as shown in the illustration, to draw out the smoke so that the men could shovel the coal over. The construction of the bunkers is such that the fan drew air over the



FAN USED TO DRAW SMOKE OUT OF COAL BUNKERS

shovelers and kept the space clear of smoke and also prevented it from entering the building. After several days of hard, dirty work the fire was reached and the smoldering coal taken out. The use of the fan greatly lessened the dirt and unpleasantness of the work of putting out the fire. The water cure resorted to on a previous occasion added to the trouble and made the fuel harder to handle. C. V. HULL.

Charles City, Iowa.

Pouring Lead Joint Under Water

As a native son of Missouri may I ask to be shown how it would be possible to pour a lead joint as described by Thomas Sheehan in the issue of Sept. 26, page 458?

Even assuming that the pouring pipe was long enough to give considerable head and was kept hot with a blowtorch and that the lead was "good and hot," it would seem that it must surely chill before filling the pipe bell, especially if the water around the pipe was cold. If the latent heat of lead is sufficient to melt the tallow and resist the cooling effect of the cast-iron pipe surrounded by water, the trick is done, but the action must be very rapid by reason of the weight or head and heat contained, somewhat like the action of "thermit," to get the lead in place before it chills. I am willing to take Mr. Sheehan's statement that it was accomplished, but would like to have the "how" explained. J. LEWIS.

New York City.

Steam-Engine Acceptance Tests

There has been considerable comment recently in the technical press regarding acceptance tests on steam-driven machinery. It frequently happens that engines and turbines are bought, accepted and paid for without testing to determine whether the builders' guarantees are actually realized or not. In general such tests can be

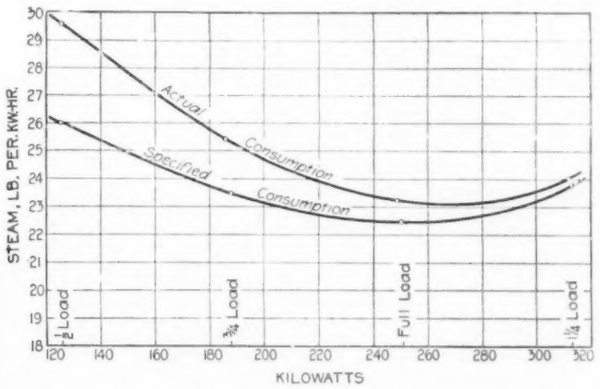


FIG. 1. ACTUAL AND SPECIFIED STEAM CONSUMPTION BEFORE CHANGING THE CYLINDERS

run without prohibitive expense or labor, and it often would prove decidedly to the customer's advantage to insist on having these tests conducted.

The City of St. Louis recently purchased two 250-kw. Corliss engines to be directly connected to two direct-current generators. These units are referred to as the north and south engines respectively. The accompanying charts show the guaranteed steam consumption and

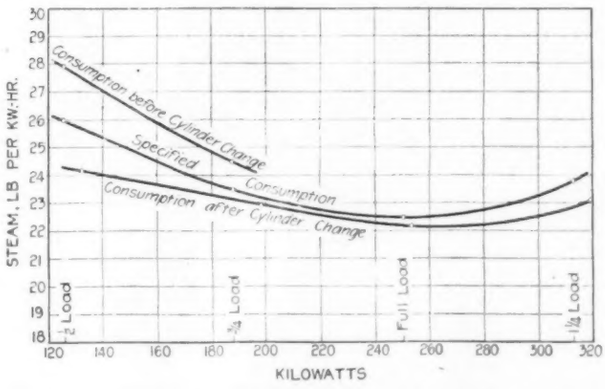


FIG. 2. STEAM CONSUMPTION BEFORE AND AFTER THE CYLINDER WAS CHANGED

the actual consumption before and after changes which were necessary in order to meet the requirements.

In the chart (Fig. 1) it will be seen that the actual consumption before the cylinder change was considerably in excess of that guaranteed on the north engine.

Chart Fig. 2 shows a portion of the actual curve of consumption for the south engine. When it was found that the consumption of this engine was also considerably in excess of the guarantees, the city insisted on the engine builders' taking hold and revising the engines in an attempt to meet the guarantees. New high-pressure cylinders having smaller clearances, highly polished heads, and tight fitting valves were furnished. The result is as shown by the lower curve in Fig. 2.

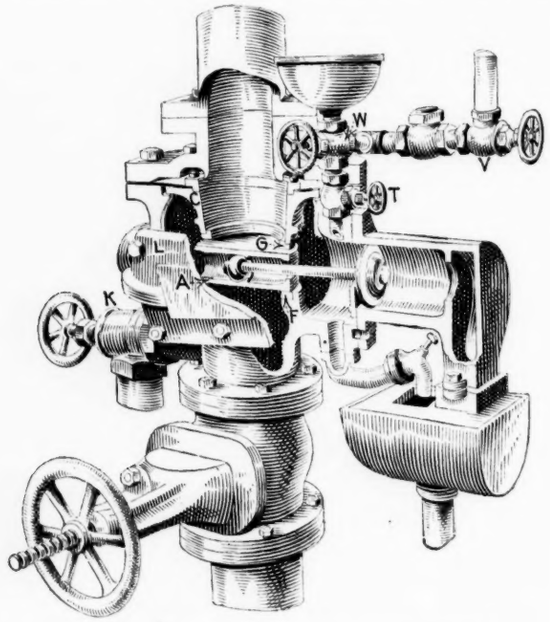
The average present load on the plant is 180 kw., and the difference in steam consumption between the engine before the change and after amounts to 1.5 lb. per kw.-hr., or a total of 270 lb. of steam per hour. The saving of steam per year becomes $270 \times 365 \times 24 = 2{,}365{,}200$ lb., and at 0.20c. per 1,000 lb. of steam the saving is $473 per year. In 15 years this would amount to $7,095, neglecting interest.

This shows clearly the value of insisting on guarantees. It probably cost the City of St. Louis $200 to accomplish these results, but it certainly was money well spent. As yet no tests have been run on the north engine since the change. L. O. Day.

St. Louis, Mo.

Sprinkler-System Experience

Last winter I had under my charge a 5-in. Model B Grinnell straightway dry pipe valve (inclosed in a small house) that controlled the water supply to about 175 sprinkler heads. The valve is set after draining the system as follows. The illustration will assist in understanding the operation. Remove the handhole plate *L* and thoroughly clean seats of gate valve *A*, raise casting *C* with the right hand, and with the left hand slide gate *A* into position against the stop, close valve *T* and prime the valve above *G* by means of funnel, then close valve



SECTIONAL VIEW OF DRY PIPE VALVE

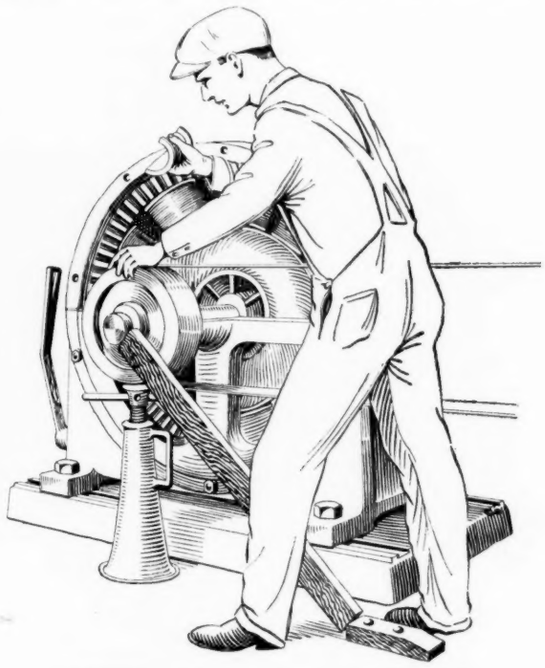
W, pump up the air pressure and tightly close valve *V*, close drain valve *K*, open main gate valve wide and see if the valve is tight at seats *F* and *G*; if so, replace the handhole plate and the job is done.

When the valve was previously set, the nuts on the handhole plate *L* were tightened up only finger tight and in the winter a sprinkler head let go, throwing the valve into action and plate *L*, not being tight, allowed a lot of water to escape and later it froze. The indicator-post valve outside the building was shut off and the drip valve opened, but when we opened the indicator-post valve later, we found the drain pipe had broken off close to the main. It was a case of digging down to get it, and as the ground was frozen for 3½ or 4 ft., this looked like a difficult job. However, the snow was removed from the place to be dug and unslacked lime piled about 2 ft. thick on the surface of the ground and allowed to stand until the following morning. This heated and softened the space so that a pick was not needed.

Springfield, Mass. Thomas Sheehan.

Removing Generator Bearing

To remove the bearing from a generator or motor without disturbing the belt or rope, place a jack so as to support the weight and a brace or prop to take the



TENSION REMOVED FROM BEARING

belt strain, as shown in the illustration. Slack the tension screw back until the bearing is loose and can be taken out. E. M. Keys, Jr.

Montesano, Wash.

Wedge Adjusting Bolts Broke

Referring to Mr. Coleman's letter in the issue of Sept. 19, page 425, about the breaking of wedge-block adjusting screws. I have had a number of them break, but in the majority of cases the screws or bolts were too short; that is, the ends screwed into the wedge lacked from ¾ to 2 in. of meeting. In renewing them I allow only about ¼ in. clearance between the ends of the bolts and have no further trouble with them. This may help other readers. G. R. Dye.

Green River, Wyo.

Inquiries of General Interest

Purpose of Hydraulic Accumulators—Why is an accumulator necessary on a hydraulic system? Could not the system be operated by direct-pump pressure? H. B.

An air-pressure accumulator or a weighted accumulator is necessary in a hydraulic system to maintain steady pressure, as pumping directly into the system would not insure steady working pressure. Employment of an accumulator not only smooths out the pressure, but also permits operation to a considerable extent without running the pumps, depending on the capacity of the accumulator.

Cross-Sectional Areas of Tubes and Uptakes—In a fire-tube boiler, what should be the ratio of the cross-sectional areas of the tubes and of the smoke uptake to the area of the grate? H. C.

In practice the ratio of the total cross-sectional area of the tubes to the area of the grate varies from ½ for a direct passage of the gases, as in vertical and locomotive boilers, to ⅛ for horizontal return-tubular boilers in which lower velocity of furnace gases and more efficient absorption of heat are obtained. For most types of fire-tube boilers it is customary to allow a cross-section of uptake equal to about ⅛ the area of the grate, though with tight connections, passages with easy bends and tall stacks, the ratio of areas of uptakes and their connections to the grate area may be considerably less, depending on the strength of the draft.

Coal Required to Compensate Condensation—Where under actual conditions, the evaporative economy of the boilers is 8 lb. of water per pound of coal, how many pounds of coal per hour would be required to compensate for heat lost by radiation from steam piping kept supplied with steam at 140 lb. gage pressure and surrounded by a room temperature of 60 deg. F.? The total surface of the piping, amounting to 2,000 sq.ft., is insulated with 85 per cent. magnesia covering 1½ in. thick. M. H.

When the pipe is surrounded by a quiet atmosphere, the radiation will be 0.418 B.t.u. to 0.456 B.t.u. per sq.ft. per hr. per deg. F. difference of temperature inside of the pipe and of the surrounding atmosphere, and to cover extreme conditions, the latter coefficient should be used. The temperature of steam at 140 gage, or 155 absolute, is 361 deg. F., and with a room temperature of 60 deg. F. the difference would be 301 deg. F. and the loss for 2,000 sq.ft. of pipe surface would be $0.456 \times 301 \times 2{,}000 = 274{,}512$ B.t.u. per hr.

This loss of heat would be supplied by the latent heat of the steam, which, for steam at 140 lb. gage, or 155 lb. absolute, is 861 B.t.u. per pound; hence $274{,}512 \div 861$ or 318.8 lb. of steam would be condensed per hour, and with an evaporation of 8 lb. of water per pound of coal, $318.8 \div 8 = 39.85$ lb. of coal per hour would be required to compensate for the heat lost by radiation from the pipe covering.

Steam Required for Heating Water—Using steam at 90 lb. gage and evaporating 8 lb. of water per pound of coal, how many pounds of coal would be required to heat 10,000 gal. of water from 45 deg. F. to 200 deg. F.? N. L.

One gallon of water at 45 deg. F. weighs 8.3448 lb. (see table, p. 542, Oct. 19, 1915, issue of "Power"). Hence 10,000 gal. would weigh 83,448 lb., and raised from 45 deg. F. to 200 deg. F. would require

$$(200 - 45) \times 83{,}448 = 12{,}934{,}440 \text{ B.t.u.}$$

One pound of steam at 90 lb. gage, or 105 absolute, has a total heat of 1,187.2 B.t.u. above 32 deg. F. If, in heating the water, the steam is condensed down to the temperature of the water, as by placing the open end of a steam pipe in the water so as to discharge the steam into the water, then, after condensing, the steam would be reduced to condensate at 200 deg. F., or $200 - 32 = 168$ deg. above 32 F., and each pound of the original steam would thereby part with $1{,}187.2 - 168 = 1{,}019.2$ B.t.u.; therefore $12{,}934{,}440 \div 1{,}019.2 = 12{,}691$ lb. of steam would be needed, requiring $12{,}691 \div 8 = 1{,}586$ lb. of coal.

If pipe coils or other condensing surfaces are employed, the steam would part with only its latent heat. As the latent heat of a pound of steam at 90 lb. gage, or 105 lb. absolute, is 885.2 B.t.u., to heat the water in this manner $12{,}934{,}440 \div 885.2 = 14{,}611$ lb. of steam would be needed, requiring $14{,}611 \div 8 = 1{,}826$ lb. of coal.

Testing Indicator Spring—How would an indicator spring be tested to know if it is true? T. S.

The calibration should be made with the spring in the indicator, and as far as possible all conditions of adjustment of the indicator should be identical with conditions under which the indicator is used with the spring in question. For practical purposes it usually will be sufficient to compare the rise of the pencil with the indications of an accurate steam gage or other pressure-testing apparatus. For that purpose the indicator and the standard instrument should be connected near together on the side of a ½-in. or larger steam pipe that is provided with a stop valve in one side of the instruments and a discharge valve on the other side, with a drip connection and valve kept open only sufficiently for drainage. By manipulating the supply stop valve and the discharge valve, different test pressures can be obtained for comparison of the indicator with the standard. The instant the desired pressure is reached, strike a pencil line on a blank card previously placed on the indicator by drawing out the drum-motion card with one hand and touching the pencil to the card with the other. Tests should be obtained on each card for equal intervals of 5 or 10 lb. pressure. When a sufficient number of pressure points have been located, close the indicator cock and draw a line on the card to establish the line of atmospheric pressure.

To check against errors in obtaining the standard pressures, a sufficient number of test cards should be made to obtain at least three cards that agree. Others should be disregarded. By making tests at equal intervals of pressures, variations in uniformity of action of the indicator are readily detected on the test cards and the indications are more easily compared with an accurately divided scale.

Volts Drop in a Three-Phase Circuit—A 60-cycle three-phase line 2 m. long transmits a load of 750 kw. at unity power factor over a 250,000-cir.mil conductor; voltage at the station end of the line is 2,300. What is the voltage drop in the line? A. A. F.

The current in the line is found by the formula,

$$I = \frac{\text{kw.} \times 1{,}000}{E \times 1.732}$$

where

I = Current in amperes per terminal;
kw. = Kilowatts delivered to the line;
E = Voltage at the station end of the line;

hence

$$I = (750 \times 1{,}000) \div (2{,}300 \times 1.732) = 188.5 \text{ amp.}$$

The voltage drop Ed in the line is made up of two components, one due to the resistance and the other to the inductance of the circuit. The volts drop caused by the resistance of the line may be determined by the expression,

$$E_r = \frac{19 \times ID}{\text{circ.mils}}$$

where

E_r = Volts drop due to the resistance of the line;
D = Length of the line in feet one way;
circ. mils = Circular-mil cross-section of the conductor;

from which

$$E_r = 19 \times 188.5 \times 10{,}560 \div 250{,}000 = 152.6 \text{ volts.}$$

The inductance component of the volts drop is

$$X = \frac{DIK \times 1.732}{1{,}000}$$

where

X = The volts drop due to the inductance of the line;
K = A constant equal to the volts drop per ampere per 1,000 ft. of wire at 60 cycles, in this case 0.12;

from which

$$X = (10{,}560 \times 188.5 \times 0.12 \times 1.732) \div 1{,}000 = 416 \text{ volts.}$$

The inductance component is displaced in phase by 90 deg. from the resistance component; therefore

$$E_d = \sqrt{E_r^2 + X^2} = \sqrt{152.6^2 + 416^2} = 443.2 \text{ volts drop}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

The Uniflow Engine*

By W. Trinks

The trend of evolution of power supply in iron and steel plants has been to electrify every machine, up to and including the main rolls, and to concentrate the power-generating apparatus in a central power house containing steam turbines in regions of cheap fuel and gas engines (with an auxiliary steam turbine for overloads) in regions of dear fuel. Into this evolution stepped the uniflow engine, which now promises or threatens (depending upon the viewpoint) to change the march of events.

In the steel-works power plant the uniflow engine will have to compete with the gas engine and with the steam turbine. The gas engine uses 7,500 to 9,500 B.t.u. per i.hp.-hr., whereas the uniflow engine, running condensing, uses from 11,000 to 13,500 B.t.u. in the steam and more in the fuel gas, depending upon the boiler efficiency. There is, in consequence, little hope of replacing the gas engine by the uniflow engine.

In comparing the engine and the turbine the variation of steam pressure and of back pressure make it advisable to leave the B.t.u. basis and to introduce Rankine-cycle efficiency, which means the ratio of the work actually produced from a unit weight of steam to the work that could be produced by the same weight of steam passing through the Rankine cycle. From a great number of published tests made on the best turbines, the author has formed the following averages for condensing operation:

Size of turbine, kw.....	500	1,000	2,000	5,000	10,000
Rankine-cycle efficiency:					
Referred to brake hp.....	0.62	0.66	0.71	0.77	0.82

For noncondensing operation the values are much lower.

Data furnished by the Stumpf Unaflow Engine Co., tests made by the author and data from the Ames Iron Works and the C. & G. Cooper Co. indicate the following efficiencies from 3 lb. per sq.in. back pressure above atmosphere down to about 23 in. of vacuum.

Size of engine, kw.....	300	600
Efficiency:		
Saturated steam.....	71	74
100 deg. superheat.....	75	77
200 deg. superheat.....	78	79
For high vacuum (about 27½ in.):		
Saturated	58	62
100 deg. superheat.....	62	65
200 deg. superheat.....	66	68

The values may vary somewhat to one side or the other, but the general tendency is apparent. For noncondensing operation, for 100 deg. superheat, for moderate vacuum, and for sizes up to 1,000 kw. the uniflow engine is more economical than the turbine. It will therefore find a place in comparatively small power plants and in such locations where 28 in. of vacuum or better is not attainable. It will also be preferred for generating direct current, because turbines for the generation of direct current, when directly connected, are too slow for best economy. If they are to operate at economical speed, gears must be introduced. Evidently the uniflow engine will have a limited field in the steel-works power plant.

For the driving of rolling mills the uniflow engine was compared with electric drive and with the older type of duoflow engine. In comparison with electric drive the steam engine does away with the electric generator, the switchboard, the transmission line and the motor, but it takes undesirable piping into the mill. The elimination of the electrical part means that a comparison must be made of the Rankine-cycle efficiency of the engine to the Rankine-cycle efficiency of the turbine, including generator, transmission line and motor. Allowing the high efficiencies of 92 per cent. for the generator, 98 per cent. for the transmission line and 92 per cent. for the motor, it is necessary to multiply the turbine efficiencies by 0.83 for comparison with the direct-connected engine. This procedure furnishes:

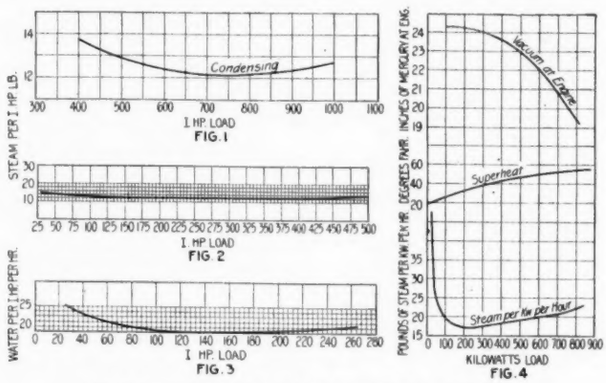
Size of turbine, kw.....	500	1,000	2,000	5,000	10,000
Rankine-cycle efficiency:					
Referred to motor shaft.....	50	54	59	64	68
Referred to mill shaft.....	47	50	55	60	64

The lower row of figures was obtained by multiplying the upper row by 0.965 × 0.965, this figure taking care of the efficiency of two speed reductions from the motor to the mill. A study of the resulting values shows that the uniflow engine is ahead of the electric drive, unless the steel plant is so large and the load such that turbo units of over 8,000-kw. capacity can be installed.

*Abstract of a paper presented at the tenth annual convention of the Association of Iron and Steel Electrical Engineers, Chicago, Sept. 18-22, 1916.

The economy of the uniflow engine compared to that of the steam-turbine electric drive, taken by itself, is not enough better to explain why the uniflow engine should fare differently from the compound engine. The Rankine-cycle efficiency of a good compound engine is practically the same as that of the uniflow engine, but there is one vital difference: To obtain that high efficiency, the compound engine must have a small high-pressure cylinder (which cuts down condensation area), but the small size of the latter means a small overload capacity and quick departure from best efficiency for comparatively small changes of load. Fig. 1 illustrates the water-rate load-curve for a well-known compound engine. Comparison of this curve with the typical water-rate curve of a 20x22-in. uniflow engine, Fig. 2, shows the latter curve to be much flatter. The uniflow engine operated at a pressure of 143 to 148 lb., a superheat of 65 to 75 deg., a vacuum of 25 to 26 in., and a speed of 200 r.p.m.

Mill loads are notoriously variable, because small variations in draft, temperature of steel, velocity of rolling, etc., cause disproportionately great changes in resistance. It is not possible to exactly foretell what the load will be, and



CHARACTERISTIC WATER-RATE CURVES

Fig. 1—Water rate of compound engine. Fig. 2—Flat water-rate curve obtained from uniflow engine. Fig. 3—Uniflow engine operated noncondensing. Fig. 4—Test results from uniflow engine

it is therefore of the utmost importance to secure a drive which permits overloading or underloading without serious change of economy.

The old-type simple duoflow engine, the old reliable standby of the rolling mill for over fifty years, cannot be considered here. It is so wasteful that its low price is more than offset by increased cost of boiler-house equipment, not to mention the continuous cost of fuel and water. It retained its place in the mill a long time by reason of its simplicity; it was replaced here and there by the compound engine on account of its wastefulness. The uniflow engine combines the simplicity and overload capacity of the simple engine with the economy of the compound; it has the added advantages that its overload capacity is even greater than that of the simple engine and that its economy is sustained over a greater range of load. Finally, it has few moving parts and takes up much less floor space than the compound engine.

Variation in back pressure naturally affects the operation of the uniflow engine. However, the vacuum may (with 4 per cent. clearance) vary from 19 to 27 in. of mercury without unduly high compression or pounding (due to lack of compression)[1]. If the vacuum fails altogether, clearance is automatically added to keep the compression down.

From personal experience the author knows that a uniflow engine with direct-current generator cost less than a geared steam turbine with generator. From this it may be concluded that an engine without generator, direct-connected to the mill, will cost less than a turbine plus generator, plus switchboard, plus motor, plus gear drive.

The secret of the economy of the uniflow engine lies principally in reduction of internal cylinder condensation. In the duoflow single-expansion engine, cylinder condensation is so great that a very great free expansion loss must be allowed for best economy (or rather for minimum wastefulness). In the compound- and triple-expansion engine cylinder con-

[1]According to experience of the C. & G. Cooper Co.

densation is reduced so that the free expansion loss can also be reduced, but mechanical losses due to the passing of the steam through so many valves become great. In the duoflow engine the cylinder head, cylinder barrel and piston head are alternately heated and cooled by live and exhaust steam sweeping over them and wiping heat "on and off." In the uniflow engine only the piston head has heat wiped off during the extremely short period of exhaust, the steam near the place of entrance of live steam being at rest like the fixed end of an expanding coiled spring during exhaust, and like that of a compression spring during compression. Besides, the cylinder head and part of the barrel are steam-jacketed, and steam-jacketed surfaces are cooled very little by stagnant steam. It may be remarked again that the mere provision of a central exhaust does not bring about a successful uniflow engine; the steam jacketing of the heads and of part of the barrel must go with it, to produce the thermodynamic superiority over the duoflow engine.

In the duoflow engine, long compression means increased steam consumption, principally because the steam temperature exceeds the cylinder (or piston) wall temperature a longer time than it would with shorter compression. In the Stumpf Unaflow engine the steam that is being compressed is in contact with progressively hotter surfaces, with the exception of that of the piston, and the steam temperature never rises much above the wall temperature.

The second reason for the economy of the uniflow engine lies in the enforced or compulsory tightness. Steam cannot leak from the live-steam space to the exhaust. If the inlet valves are leaky to any extent, the compression rises so quickly that the inlet valves clatter and give notice to the engineer that something is wrong.

The development of the uniflow engine in the United States has been slow, probably because it did not fit into the general trend of changing from reciprocating to rotating machinery, and because it is of foreign origin. It began in a small way in 1912. The C. & G. Cooper Co., of Mount Vernon, Ohio, the Nordberg Mfg. Co., of Milwaukee, Wis., and the Mesta Machine Co., of Pittsburgh, Penn., began almost simultaneously to build experimental engines. All three firms moved cautiously and equipped their engines with the "old reliable" Corliss gear; all three found out that the Corliss releasing gear, in its usual form, is not ideal for the uniflow engine, because the cutoff is so short, because modern plants carry high pressure with superheat and because the pressure drops so fast after cutoff that the valve becomes unbalanced too quickly for the ordinary design and size of vacuum pot. In consequence, the Mesta Machine Co. and the Nordberg Co. switched over to poppet-valve gears, while the Cooper Co. adapted its Corliss gear and vacuum pot to the new conditions. The Mesta Machine Co., licensed by the Stumpf Unaflow Engine Co., made its poppet-valve gear nonreleasing, while the Nordberg Co. adopted a releasing gear. The latter type did not find favor with German engineers on uniflow engines; they claim that it is not adapted to the short cutoff required. It remains to be seen whether the skill of the engineers of the Nordberg Co. has overcome the alleged difficulties.

The smaller sizes of uniflow engines have been developed by the Ames Iron Works, of Oswego, N. Y., and by the Skinner Engine Co., of Erie, Penn. The Ames Iron Works are licensed by the Stumpf Unaflow Engine Co., holders of the Stumpf patents. The Ames Iron Works, from the very beginning, adopted poppet-valve steam distribution, with shaft governor drive. This design is well adapted for small engines up to 400 or 500 hp. and is very successful. For larger sizes and high steam temperature it is not so well suited, because the difference in expansion between the valve rod and the cylinder becomes too great and disturbs steam distribution. For poppet-valve engines above 500 hp. the layshaft drive is preferable.

In the sizes built by the Ames Iron Works, a self-supporting piston guided at the crank end only is perfectly satisfactory. In larger sizes this same design leads to a great deal of trouble. On account of difference in expansion the piston must be a loose fit in the cylinder. The guiding of the piston by the crosshead is imperfect. The piston, therefore, wabbles around in the cylinder, riding now on one spot, then on another, never wearing itself in, but rapidly wearing itself out. In large engines of German design a tail-rod guide has been provided, not so much for the purpose of carrying the piston, but mainly for the purpose of guiding it so that it will always touch the cylinder in a large surface. American engineers have gone one step farther and have made the piston rod strong enough to carry the piston.

The early part of the practical development was thorny. Cracked cylinders, heads and bedplates caused trouble; valve-gear troubles and regulation troubles had to be overcome, pistons and cylinders wore too rapidly. But the problems have all been solved, and the future promises to be free from any obstacles whatsoever. Whatever troubles were experienced, naturally appeared more forcefully in the larger sizes, with the result that the smaller sizes, developed by the Ames Iron Works and the Skinner Engine Co., have made more progress in numbers than the larger sizes. It can safely be said that the uniflow engine today is as reliable as the simplest engine of the duoflow type.

Figs. 3 and 4 show the steam consumption of various types and sizes of uniflow engines. The results in Fig. 3 were obtained from a 19x22-in. engine operating on saturated steam at 125-lb. pressure and atmospheric exhaust. Its normal rating is 240 i.hp., and the speed is 200 r.p.m. Fig. 4 was made up from actual test results obtained from larger engines.

The Old Story—A Birmingham professor is credited with the suggestion that by a very simple method a considerable saving in fuel—coal, coke, etc.—may be effected. His way is to melt a fairly large soupspoonful of salt in a half-liter of water and to sprinkle with a small sprinkler 50 kg. of the fuel. Thus to treat 500 kg. of the fuel it is necessary to use 400 or 500 grams of salt. The salt possesses the property of absorbing smoke; that is to say, the smoke is burned in place of escaping without producing heat and coating the flues with soot. He declares that by this means he has realized a real economy, and it has been very noticeable that when the bars are cleaned out after this method has been used there is very little dross left, which proves that a more complete combustion has taken place. The British "Bakers' Helper" says the hint is worth consideration by bakers, and where the methodical practice of weighing or measuring coal is daily carried out the proportion of salted water to the quantity of fuel used can easily be estimated. Engineers who make ice cream during spare moments can now utilize the brine.

Work of Running a Flywheel—A revolving flywheel acts to an extent like a fan. Air drawn in near the center is thrown outward by centrifugal force, and all the work of pumping this air and of the resistance of the arms and other surfaces of the flywheel is included in the useless work. In a recent issue of "Engineering," A. Vincent Clarke, A. M. I. C. E., M. I. M. E., tells of a test made on one of Davey, Paxman & Co.'s horizontal engines having a flywheel 16 ft. in diameter grooved for 16 ropes, made with double arms and run at 100 r.p.m. The power required to run the engine, with the ropes removed, as determined by the indicator, was 61 hp. After the flywheel arms had been boarded up, the friction diagram taken in the same condition as before showed that the power was reduced to 48 i.hp.

Lubrication of Poppet-Valve Engines—The Thomas S. Watson Co., engineers, Milwaukee, give the following report covering the cost of lubricating the cylinder of a 20x32, 150-r.p.m. poppet-valve Nordberg engine using superheated steam, at the plant of the Rockwell Manufacturing Co., and say that it surpasses any previous record to which they have had access:

Steam pressure, lb. gage	150
Average superheat, deg. F.	120
Average temperature, deg. F.	485
Time, hr.	224.5
Gallons cylinder oil	2
Cost at 55c.	$1.10
Surface swept by rings per rev., sq.ft.	27.92
Surface swept per hour, sq.ft.	251,280
Surface swept for total time, sq.ft.	56,412,360
Surface swept per gallon, sq.ft.	28,205,180
Surface swept for 1c., sq.ft.	512,840

Largest Cooling Tower—What is believed to be the largest natural-draft cooling tower so far built has recently been completed at the Anderson, Ind., plant of the American Steel and Wire Co. This tower is of the Wheeler-Balcke type, built by the Wheeler Condenser and Engineering Co., is approximately 150 ft. long, 50 ft. wide and 75 ft. high, and has a yellow-pine frame with cypress sheathing and filling. It has two chimneys which create an air circulation by natural draft. The capacity of the tower is 7,300 gal. per min. cooled from 115 to 85 deg.

Cost of Making Gasoline by the Rittman process, as shown by the United States Bureau of Mines in a recent report, is from 7.8 to 13.9c. per gal. The variance in the cost is due to a wide difference in the price of the residuum used as the base of the process in the tests. This difference in price of fuel oil was assumed in order that production cost could be estimated both for low- and high-priced crude. The figures show a recovery of only 17 per cent. of gasoline, as compared with 80 per cent., which was announced for the process when its discovery was first made public.

Report on the Power Session of the British Association

By Special Correspondence

SYNOPSIS—A comparison is made of the various coal resources of the earth and their geographical distribution. The rate of increase in the world's demand for this kind of fuel and what may be done best to utilize this source of power are also discussed.

Power problems loomed large in the program of subjects for discussion at this year's meeting of the British Association, for the engineers and chemists combined and devoted a whole session to the consideration of the preliminary report presented by the committee appointed at Manchester last year to investigate the allied problems of fuel economy and the better utilization of the fuel resources of the earth.

The interest of this first report, for American readers, lies chiefly in the comparison of the fuel resources of the various

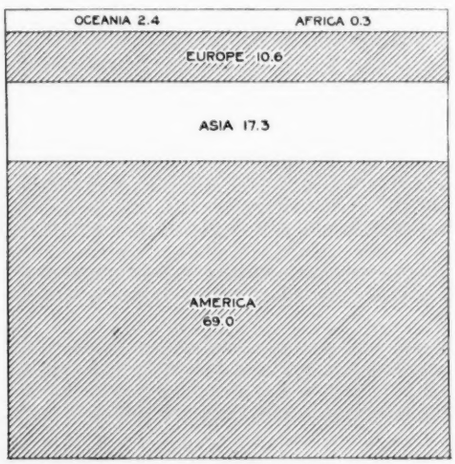


FIG. 1. DISTRIBUTION OF THE WORLD'S COAL RESOURCES

countries of the world and in its clear recognition of the fact that the American Continent possesses the greatest reserves of unused coal. The committee states that if anything ought to arouse public opinion to the gravity of the situation, it is afforded by the statistics published in the report upon the world's coal resources issued by the International Geological Congress in the year 1913. According to this estimate, the geographical distribution of the world's possible and probable reserves of coal of all kinds, available within 6,000 ft. of the earth's surface amounts to 7,397,553 million metric tons (2,-204.6 lb.) and may be represented diagrammatically as in Figs. 1 and 2, which show that the American Continents contain 69 per cent. of the world's coal supply.

The fact that the available reserves of coal in Great Britain amount to only about one-fortieth, while those of the whole Empire are not more than about one-fourth, of the world's estimated total is one that ought to be brought home to everyone responsible for the economic development of the country's national and imperial resources—especially in view of the fact that the United States, whose competition in the immediate future will probably be much more severely felt than ever before, possesses more than half the estimated world's coal, and that also in regard to the two prime considerations of quality and cost of production she probably compares favorably with Great Britain and the Empire.

A reference to the important investigations and research work carried out by the United States Government and the University of Illinois follows, and it is stated that in consequence of this, American manufacturers have at their disposal much more complete and systematic information about their country's coal resources than is at present possessed by their British competitors.

Passing on to consider the world's demand for coal, the report states that the rapid increase in recent years is shown by the approximate figures given in Table 1, covering the ten years' period immediately antecedent to the outbreak of war.

TABLE 1. WORLD'S DEMAND FOR COAL

Year	Approximate Total, Millions of Tons
1903	800
1908	1,000
1913	1,250

From these figures it would appear that during the period in question the world's demands have continuously increased at a compound-interest rate of nearly 5 per cent. per annum. Another important fact is that these demands have been principally met by three countries—the United States, Great Britain and Germany—which between them have hitherto annually supplied 83 per cent. of the total anthracite and bituminous coal consumed in the world. This being so, it is of interest to compare the relative rates of increase in coal production of these three countries during recent years. This may best be deduced from a comparison of quinquennial averages over a period of 15 years, 1900-14, as given in Table 2.

TABLE 2. COAL PRODUCTION OF THE UNITED STATES, GREAT BRITAIN AND GERMANY

Quinquennial Averages, 1900-14

Period	Millions of Tons per Annum: United States	Great Britain	Germany
1900-04	288.2	226.8	112.5
1905-09	400.5	256.0	139.8
1910-14	519.2	269.9	168.3

From these figures it may be inferred that up to the outbreak of the war the coal output of the United States was increasing annually at a compound-interest rate of about 6 per cent., that of Germany at a compound-interest rate of about 4 per cent., while the British output was increasing at a compound rate of 2 per cent. only. During the period 1910-14 the United States produced nearly twice as much coal as Great Britain, and assuming that these relative rates of increase are maintained after the war, it may be predicted that Germany's output of coal will overtake that of Great Britain about twenty years hence, when each country will be producing some 420,000,000 tons per annum.

The public cannot be too often reminded that not only is coal of prime importance as a fuel, but also, when properly handled by the chemist, it yields very valuable byproducts, which are the raw materials of important industries. Thus

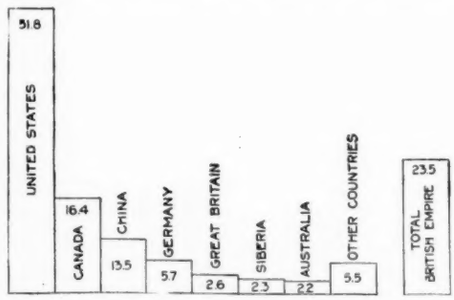


FIG. 2. COMPARISON OF THE WORLD'S COAL RESOURCES AS DISTRIBUTED IN THE DIFFERENT COUNTRIES

from coal tar and other byproducts of its distillation are obtained the raw materials for the manufacture of both synthetic dyes and drugs and certain high explosives. Another important byproduct obtainable is ammonia in the form of sulphate, which is chiefly used as a fertilizer in the production of food-stuffs. The use of artificial fertilizers, including ammonium sulphate, by agriculturists is still in its infancy, and the near future ought to see a large expansion in the demands for nitrogenous fertilizers.

Having thus discussed the general statistics of coal production, the report next gives an outline of the organization that has been set up to deal with the whole question in a sufficiently broad and scientific manner, and states that, having regard to the magnitude of its work and the fact that the coal question is one upon which almost every branch of manufacturing and transportation is dependent, the original committee of 13 members appointed by the association in October, 1915, decided to exercise somewhat freely its powers of co-option, so as to make a general committee sufficiently large

and representative of all the important interests involved. The general committee at present has a membership of 46.

For a more detailed and special study of the particular aspects of the fuel question the enlarged general committee has resolved itself into the following five subcommittees: (a) Chemical and Statistical; (b) Carbonization; (c) Metallurgical, Ceramic and Refractory Materials; (d) Power and Steam Raising; (e) Domestic Heating and Smoke Prevention. Memoranda relating to the work of these various subcommittees during the year are attached to the report as an appendix. Some extracts from the report of the committee appointed to consider the use of coal for power- and steam-raising purposes are given, and they indicate the magnitude of the work undertaken by this committee: It has been decided to deal with this branch of the subject under the following heads:

1. To consider (a) the amount of fuel consumed and (b) the corresponding power developed in the United Kingdom under the following heads: Factories, Mines, Railways, Ships and Steam Raising for Other Purposes than Power.

2. To consider the present position of central electrical power plants and gas undertakings as regards power supply.

3. To discuss the relative merits of the present methods for producing power by steam, gas, oil and petrol engines respectively.

4. To investigate the possible fuel saving that might be effected (a) by improved plant, (b) by greater centralization of power production, (c) by coördination with metallurgical and other manufacturing processes, (d) by some measure of public control, (e) by better supervision and (f) by the use of fuels of inferior grades that are at present wasted.

The average figure of 5 lb. of coal per horsepower-hour, which was given in the report of the Royal Commission on Coal Supplies in 1905, was deduced from returns from a number of typical industrial concerns where information could be obtained, and it is probable that this estimate did not exaggerate the actual coal consumption per horsepower-hour at that time. In view of the impossibility of obtaining accurate returns of fuel consumption per horsepower-hour from the whole of the power users in the United Kingdom, it has been decided to investigate the matter by asking for detailed returns from typical factories in various trades and in different districts throughout the country, selected by members of the subcommittee who have special knowledge of particular trades.

Special memoranda are also in course of preparation on questions of organization of power production for industrial and transportation purposes, the use of large turbine and gas engines, and other important aspects of the power question.

I. C. S. Celebrate Anniversary

The International Correspondence Schools celebrated their twenty-fifth anniversary on Oct. 2 in conjunction with the fiftieth anniversary of the City of Scranton, Penn. Formal exercises were held in the Strand Theater during the afternoon. The principal address was made by R. H. Conwell, D.D., LL.D., president of Temple University, his theme being that the Scranton schools had reversed the process of education. Instead of asking students to come to their halls, they have gone to the students and have reached over a million and a half. The present enrollment is a quarter of a million, including the various branches.

A special feature of the afternoon exercises was a trip through the school buildings by moving pictures. In the evening a banquet was served to 450 in the Educational Building. The principal toasts were given by Governor Martin G. Brumbaugh, of Pennsylvania, and Rear Admiral Austin M. Knight, U. S. A.

The I. C. S. is to be congratulated on the splendid record of 25 years and the great promise of future usefulness.

ENGINEERING AFFAIRS

The Associated Business Papers will hold its annual convention at the Hotel Astor, New York City, Oct. 26-28.

The Electric Power Club will hold its next meeting in Hot Springs, Va., Nov. 15-18, with headquarters at the Homestead Hotel.

The Detroit Engineering Society announces that Frank B. Gilbreth will give an illustrated talk on "Time Studies" at its meeting on the evening of Oct. 20.

The American Society of Mechanical Engineers' Buffalo Section, announces that the topic for its meeting on Nov. 1 will be a talk on "Motion Study" by Frank B. Gilbreth. On Nov. 15 Mr. Russell, of the Burgess Aëroplane Co., will talk on an aëroplane topic of general interest.

National Association of Stationary Engineers—The combined entertainment and ball of the associations of the N. A. S. E. of Manhattan and the Bronx will be held Saturday, Nov. 4, at Lexington Opera House (Terrace Garden), Fifty-eighth St., near Third Ave., New York City. As usual the national officers will be present.

The American Association for the Advancement of Science will meet in New York City during the last week of December, under the auspices of Columbia University, New York University, the College of the City of New York, the American Museum of Natural History, and the other scientific and educational institutions of the city. This is the sixty-ninth meeting of the American Association, which was established in 1848, and is the first of the greater convocation week meetings, to be held hereafter once in four years, successively in New York, Chicago and Washington. Section D of the society is devoted to mechanical science and engineering.

The Philadelphia Safety Council held its monthly meeting at the Franklin Institute on Tuesday evening, Oct. 3. The topics were the new elevator and boiler codes recently adopted by the Department of Labor and Industry of the State of Pennsylvania. The meeting was presided over by H. W. Foster, president of the council. The features of the elevator code were presented by W. McD. Manning, engineer of the Otis Elevator Co., who discussed matters of interest to operating engineers and users of elevators and described the particular features concerning the safe operation of the various classes of elevators dealt with. The requirements for hand-operated elevators, he said, were so rigid that their use was practically prohibited, and he predicted that this portion of the code would have to be revised. The subject of the boiler code for the State of Pennsylvania, which has lately adopted the code put out by the American Society of Mechanical Engineers, was discussed by S. F. Jeter, Chief Engineer of the Hartford Steam Boiler Inspection and Insurance Co. The general features of this code of interest to the operator, and particularly Part 2 referring to boilers already installed, were discussed by the speaker. Questions asked from the audience were answered by speakers at the close of each paper. John M. Lukens, chief inspector for the City of Philadelphia, was asked by the presiding officer to state the position of the City Boiler Inspection Department with respect to the new code. Mr. Lukens said that the consent of the mayor had been obtained to draft a new city ordinance with respect to the inspection and installation of boilers. This draft, providing for the adoption of the A. S. M. E. Code in its entirety by the city, was to be presented at the next regular meeting of the city council with good prospects that it would be passed. This statement was received with enthusiastic applause. Mr. Lukens stated that he did not approve of every feature of the A. S. M. E. Code, but in the interest of uniformity he was willing to accept it without change. In adopting this code Philadelphia will be replacing the oldest set of boiler rules in this country, as their old rules for boiler inspection have been in existence since 1868.

NEW PUBLICATIONS

EXAMPLES IN ALTERNATING CURRENTS. Vol. 1. By F. E. Austin. Published by the author at Hanover, N. H. Second edition; flexible leather; 5x7½ in.; 223 pages; 70 illustrations; tables. Price, $1.10.

APPLIED ELECTRICITY FOR PRACTICAL MEN. By Arthur J. Rowland. McGraw-Hill Book Co., Inc., New York. Cloth; 5x7½ in.; 375 pages; 323 illustrations. Price, $2.

ELEVATORS. By John H. Jallings. American Technical Society, Chicago. Cloth; 5½x8½ in.; 217 pages; 172 illustrations. Price, $1.50.

The author has spent over twenty years as an elevator engineer and this indicates the character of the book, which is divided into three parts—the first on elevators generally, the second on steam and hydraulic and the third on electric elevators. Naturally, most of the book is descriptive of types of elevators, and the author has provided so many good perspective and detail drawings together with the photographs that the book may be made useful indeed to the "man on the job."

Of course the most recent types of machines and their appendages are treated of and illustrated. In these days when the electric elevator is so widely used, wiring diagrams of the control board are always welcomed by those responsible for the care of the machinery. Mr. Jallings' section on control is commendable, yet one feels a little disappointed not to find wiring diagrams of control boards of more than one or two elevator makers. To be specific, there are too few such dia-

grams of machines manufactured by a company that leads in elevator construction, output considered, and therefore makers of types most frequently met with by operators. This may be due to the reluctance of the makers to supply the author with the diagrams; at any rate their absence is disappointing.

The average reader would be pleased to find a chapter devoted to the care and management of elevators, as there are many things applicable to all elevators, particularly hydraulic machines, that those responsible for the machinery should know and which they would like to find in one chapter. On the whole the book is the best on the subject of elevators, hydraulic and electric, that has come to our attention to date. There has for long been need of a book on electric elevators, the only connected and thorough treatment of them ever written before Mr. Jallings' chapters on them in his book were by William Baxter, Jr., and published in "Power" during 1909, 1910 and 1911. Unfortunately Mr. Baxter died before he finished the series, although they are quite complete.

MISCELLANEOUS ITEMS

North Memphis Pumping Station—Attention has been called to a typographical error in the article on the North Memphis Pumping Station, p. 442, Sept. 26 issue. The total cost should have been $275,000 instead of $75,000, as given.

Crankpins Will Heat if not large enough to do the work, if good lubrication is not provided, if dirt gets inside the brasses, if the brasses are not properly fitted, or if the brasses or pin are not of good material and in a smooth condition. Being out of line or keyed too tightly also causes them to heat.

Test Papers are made by dipping unsized paper into a solution of a vegetable coloring matter which changes its color when exposed to the action of acid or an alkali. The paper, after being dried, is cut into strips of a suitable size. Then by dipping the appropriate test paper into any solution its nature can be ascertained whether it is acid, alkaline or neutral. Litmus and turmeric are most commonly used as coloring matter—litmus for the detection of acid and turmeric for detecting alkalies.

The Coefficient of Heat Transference in Condensers, or the number of heat units transferred per hour through 1 sq.ft. of metallic condenser wall when the temperature of the steam is 1 deg. F. higher than that of the water, for various metals of the usual thickness or about 0.04 in., is fairly well established for ideal conditions and may be given as 18,430 for brass, 61.500 for copper, 11,270 for iron, 5,740 for zinc, 11,050 for tin and 2,660 for aluminum. In everyday practice, however, little difference is observed between copper and iron tubes.

Engineers to Assist in National Research Council—Arrangements have just been completed in New York whereby the resources of the Engineering Foundation, under the auspices of the four principal national engineering societies, are placed at the disposal of the National Research Council, which was appointed by the National Academy of Science at the request of President Wilson. The object of the council is to coördinate the scientific research work of the country in order to secure efficiency in the solution of the problems of war and peace. The council was without funds until the Engineering Foundation, established to further scientific and engineering research, offered to place its resources at the council's disposal, including the services of its secretary, Dr. Cary T. Hutchinson, to act as secretary of the council. The offer was accepted, and plans for immediate activities have been placed in the hands of an executive committee.

Income from Waste—A box factory in Ohio utilizes all its so-called waste products from which an income may be derived. The plant in question manufactures boxes of soft air-dried wood and for this purpose purchases about 8,500 kw.-hr. per month from the local central-station company. The waste-product or byproduct of this plant is wood in the form of shavings and sawdust. In the ordinary way the sawdust and shavings would probably be considered as refuse and used under their own boilers or for the dry kilns. Part of the shavings and sawdust is used under the kilns, but the excess is passed through a cyclone separator. The sawdust is sold to ice makers for insulating purposes and to merchants for packing their goods, for about $2.50 per wagonload. The shavings are made up into bales of about 80 lb. each and sold at about 25c. per bale, mostly to breweries to pack their bottles in and to spread over floors. Thus about $200 per month is realized from what would ordinarily be considered refuse.

Proposed Construction

Arizona, Tucson—City to vote in December on $200,000 bonds for improving light and water systems.

Calif., Alameda—Union Iron Works plans to construct a power house. About $22,500.

Calif., Sausalito—Sausalito Gas Co. plans to build electric-light and gas plant. J. E. Bell, San Jose, president.

Conn., New Haven—Connecticut Co. granted permit, 2-story, 78x148-ft. power house on Grand Ave. About $250,000.

Fla., Vero—N. J. Norman, St. George, Ga., interested in installation of electric-light plant in Vero.

Ill., Germantowa—City making plans for electric-light plant. V. J. Kluthe, 915 Olive St., St. Louis, Mo., architect.

Ill., Rockford—D. H. Maury, engineer, Chicago, in report to Council, recommends the installation of an electric-light plant and system. About $425,000.

Kan., Genesco—City plans to install distribution system.

Kan., Huron—Bonds sold for installation of electric-light system.

Kan., Springhill—City election Oct. 23 to vote on $4,000 bonds for improving electric-lighting system.

Ky., Arlington—Citizens plans to install electric-light and power plant. A. U. Given, chairman of committee.

Ky., Lancaster—Bastin Bros. plan installation of power plant.

Ky., Paintsville—Citizens plan electric-light plant. J. Buckingham is interested.

Mass., Lunenburg—Town plans extension of electric-lighting system to Goodrichville, Mulpus and Flat Hill. A. A. Coop, commissioner.

Minn., Gary—Village granted franchise to J. F. Heiberg, to install electric-lighting system.

Minn., Goodridge—Village plans to install electric-light system.

Minn., Granada—Council plans electric-light system.

Minn., Hoffman—City voted $10,000 bonds for municipal electric-lighting system and plant.

Minn., Mazeppa—City voted $8,000 bonds for electric-light and power plant.

Mo., Mt. Vernon—Citizens voted bonds to rebuild electric-light plant destroyed by fire. A. G. Moore, Frisco Bldg., Joplin, engineer.

Mont., Malta—Standard Electrical Engineering Co. granted franchise by city to install electric-light and power plant.

Mont., Melstone—City Council soon to receive bids for electric-light plant.

Neb., Bancroft—City sold $12,000 electric-light plant bonds.

N. J., Belleville—Kent Motors Co. plans power plant in connection with manufacturing plant in Hillside Sect. Marvin & Davis, 303 Fifth Ave., New York, architect.

N. J., Boonton—Boonton Electric Co. granted permission by Board Utility Comrs. to issue $20,000 bonds for extensions and improvements.

N. J., Newark—German Hospital plans power house on Bank St.

N. J., Newton—Town plans appropriation of $8,000 for installing electric-light system.

N. Y., Dannemora—(Official)—J. M. Carter, superintendent Prisons, Capitol, Albany, receiving bids Oct. 18 for engine and generator for Dannemora State Hospital.

N. Y., Eden—Niagara & Lake Erie Power Co., Fredonia, petitioned public service commission for permission to extend transmission line to Eden and install system.

N. Y., Middletown—Orange County Lighting Co. to install lighting system on North St. H. A. Cox, Middletown, engineer, power station.

N. Y., Port Henry—Port Henry Light, Heat and Power Co. has increased its capital stock and will make improvements to its system.

N. D., Grand Forks—City plans to install electric-light plant. W. E. Skinner, Plymouth Bldg., Minneapolis, Minn., engineer.

N. D., Medina—E. P. Olson interested in installation of electric-light plant.

Okla., Oklahoma—Blue River Power Co. to build hydro-electric plant. J. Martz, Seward, Neb., manager and superintendent.

Penn., Philadelphia—Electrical Bureau prepared plans for new electric power plant in city hall, about $90,000. J. F. McLaughlin, chief of bureau.

Que., Beauharnois—Howard Smith Paper Co. making plans for addition to power plant. R. S. Kelsch, Power Bldg., Montreal, architect.

Tex., Galveston—Galveston Gas Co. plans to spend about $42,000 for improving its plant.

Wash., Port Angeles—City plans to improve and extend the lighting system. About $5,000.

Wash., South Cle Elum—Bonds for $5,000 voted for installation of electric-light system.

Wis., Clyman—Wisconsin Gas and Electric Co., Kenosha, plans extending transmission line to Clyman.